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FINAL DENITRIFICATION BASED BIOREMEDIATION TREATABILITY STUDY WORK PLAN  
FOR UNDERGROUND STORAGE TANK 18 NAS PENSACOLA FL  
3/1/2010  
TETRA TECH

# **C**omprehensive **L**ong-term **E**nvironmental **A**ction **N**avy

CONTRACT NUMBER N62467-94-D-0888



## **Denitrification-Based Bioremediation Treatability Study Work Plan for UST Site 18**

**Naval Air Station Pensacola  
Pensacola, Florida**

**Contract Task Order 0063**

**March 2010**



NAS Jacksonville  
Jacksonville, Florida 32212-0030

**DENITRIFICATION-BASED BIOREMEDIATION  
TREATABILITY STUDY WORK PLAN  
FOR  
UST SITE 18**

**NAVAL AIR STATION PENSACOLA  
PENSACOLA, FLORIDA**

**COMPREHENSIVE LONG-TERM  
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT**

**Submitted to:  
Naval Facilities Engineering Command Southeast  
NAS Jacksonville  
Jacksonville, Florida 32212-0030**

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**CONTRACT NUMBER N62467-04-D-0055  
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**MARCH 2010**

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# TABLE OF CONTENTS

<b><u>SECTION</u></b>	<b><u>PAGE NO.</u></b>
<b>ACRONYMS/ABBREVIATIONS .....</b>	<b>v</b>
<b>1.0 INTRODUCTION.....</b>	<b>1-1</b>
1.1 INTRODUCTION.....	1-1
1.2 SITE OVERVIEW .....	1-1
1.3 OBJECTIVES OF THE STUDY .....	1-2
1.4 DOCUMENT ORGANIZATION .....	1-2
<b>2.0 SITE CONDITIONS.....</b>	<b>2-1</b>
2.1 GEOLOGY AND HYDROGEOLOGY .....	2-1
2.2 PREVIOUS INVESTIGATIONS .....	2-1
<b>3.0 TREATABILITY STUDY SUMMARY .....</b>	<b>3-1</b>
3.1 TREATABILITY STUDY.....	3-1
3.2 TREATMENT GOALS.....	3-1
3.3 EXPANDED REMEDIATION .....	3-2
<b>4.0 TREATABILITY STUDY DESIGN AND IMPLEMENTATION.....</b>	<b>4-1</b>
4.1 STUDY DESIGN .....	4-1
4.1.1 Technology Selection.....	4-1
4.1.2 Location Selection.....	4-3
4.1.3 Bio-Trap Sampler .....	4-3
4.1.4 N-Blend Amendment Injection .....	4-4
4.1.4.1 Regulatory Conditions for N-Blend Injection .....	4-4
4.1.5 Groundwater Monitoring.....	4-5
4.2 STUDY IMPLEMENTATION .....	4-6
4.2.1 Baseline Sampling .....	4-6
4.2.2 Bio-Trap Sampler Placement.....	4-6
4.2.3 N-Blend Nutrient Injection.....	4-7
4.2.4 Post-Study Sampling.....	4-7
4.3 ANALYTICAL APPROACH.....	4-8
4.4 REPORTING .....	4-8
<b>5.0 SAMPLING AND IDW HANDLING PROCEDURES.....</b>	<b>5-1</b>
5.1 SAMPLING PROCEDURES .....	5-1
5.1.1 Groundwater Sampling .....	5-1
5.1.2 Quality Assurance / Quality Control Samples .....	5-1
5.1.3 IDW Samples .....	5-2
5.2 SAMPLE HANDLING .....	5-2
5.2.1 Field Documentation .....	5-2
5.2.2 Sample Nomenclature.....	5-2
5.2.3 Sample Packaging and Shipping .....	5-4
5.3 SAMPLE CUSTODY .....	5-5
5.4 INVESTIGATION-DERIVED WASTE HANDLING.....	5-5
5.4.1 Development and Purge Water.....	5-5
5.4.2 Decontamination Fluids.....	5-6
5.4.3 Personal Protection Equipment and Miscellaneous Trash .....	5-6
<b>REFERENCES.....</b>	<b>R-1</b>



## TABLE OF CONTENTS (Continued)

### **APPENDICES**

<b>A</b>	<b>TREATABILITY STUDY AMENDMENT AND SAMPLER SPECIFICATIONS</b>
<b>B</b>	<b>STANDARD OPERATING PROCEDURES</b>
<b>C</b>	<b>FIELD DATA COLLECTION SHEETS</b>
<b>D</b>	<b>N-BLEND COMPOSITION and ZOD ESTIMATION (CONFIDENTIAL INFORMATION)</b>
<b>E</b>	<b>UIC MEMORANDUM</b>
<b>F</b>	<b>MONITORING WELLS WITH FLORIDA NADSCs EXCEEDANCES</b>

### **TABLES**

#### **NUMBER**

4-1	Sampling and Analysis Summary
4-2	Summary for Data Uses for Analytical Parameters

### **FIGURES**

#### **NUMBER**

1-1	Site Location Map
1-2	Site Map
4-1	Treatability Study Well Layout

## ACRONYMS/ABBREVIATIONS

bgs	Below ground surface
BTEX	Benzene, toluene, ethylbenzene, and xylenes
<sup>13</sup> C	Carbon - 13
CAR	Contamination Assessment Report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	Contaminant of concern
CTO	Contract Task Order
DBB	Denitrification-based bioremediation
DO	Dissolved oxygen
DOT	Department of Transportation
DPT	Direct push technology
DQO	Data Quality Objective
EAH	Ensafe/Allen & Hoshall
F.A.C.	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FL-PRO	Florida Petroleum Range Organic Method
GCTL	Groundwater Cleanup Target Level
IDW	Investigation-derived waste
IR	Installation Restoration
LNAPL	Light non-aqueous phase liquid
MNA	Monitored natural attenuation
MS	Matrix spike
MSD	Matrix spike duplicate
NADSC	Natural Attenuation Default Source Concentration
NAS	Naval Air Station
NAVFAC SE	Naval Facilities Engineering Command Southeast
ORP	Oxidation/reduction potential
PAH	Polynuclear aromatic hydrocarbon
PID	Photoionization detector
PLFA	Phospho-lipid fatty acid
PPE	Personal protection equipment
QA	Quality assurance
QC	Quality control
RAP	Remedial Action Plan
SARA	Site Assessment Report Addendum

## ACRONYMS/ABBREVIATIONS (CONTINUED)

SIP	Stable isotope probing
SOP	Standard Operating Procedure
SVE	Soil vapor extraction
TRPH	Total recoverable petroleum hydrocarbons
TtNUS	Tetra Tech NUS, Inc.
UIC	Underground injection control section
µg/L	Microgram per liter
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VFA	Volatile fatty acid
VOC	Volatile organic compound
ZOD	Zone of discharge

## **1.0 INTRODUCTION**

### **1.1 INTRODUCTION**

Tetra Tech NUS, Inc. (TtNUS) has been contracted by Naval Facilities Engineering Command Southeast (NAVFAC SE) to conduct a groundwater remediation treatability study at Underground Storage Tank (UST) Site 18 at Naval Air Station (NAS) Pensacola located in Pensacola, Florida. The focus of this treatability study is to evaluate the potential for denitrification-based bioremediation (DBB) to mitigate volatile organic compounds (VOCs) detected at concentrations greater than Florida Department of Environmental Protection (FDEP) Groundwater Cleanup Target Levels (GCTLs) as specified in Chapter 62-777, Florida Administrative Code (F.A.C.). The DBB process utilizes nitrates as electron acceptors and as a nutrient source to promote anaerobic biodegradation of petroleum constituents in groundwater. This work will be performed under Contract Task Order (CTO) 0063 of Comprehensive Long-term Environmental Action Navy (CLEAN) Contract No. N62467-04-D-0055. This work plan presents the rationale and proposed approach for the treatability study. The United States Environmental Protection Agency (USEPA) Data Quality Objective (DQO) Process (USEPA, 2006) was used as a tool for the generation of this work plan and have been incorporated throughout the work plan document.

### **1.2 SITE OVERVIEW**

UST Site 18 is located at NAS Pensacola in Escambia County, Florida, and occupies approximately 47.5 acres of open land along the southwestern border of Forrest Sherman Field. The site is bordered to the east by aircraft Runway 19, to the north by a paved taxiway, to the west by scattered brush and woods, and to the south by an open field. A general site vicinity map is included as Figure 1-1. Site features are shown on Figure 1-2.

Between 1955 and 1997, the UST Site 18 area was used to train firefighters for aircraft crash responses, using available fuel as a combustion source. Historically, during training exercises, approximately 30 to 700 gallons of fuel were poured into unlined pits or onto various pieces of equipment and then ignited to simulate aircraft crashes. Four circular pits can be seen on Figure 1-2, and historical photographs show eight former burn pits.

The northernmost pit, which was lined and filled with water, contained a mock aircraft cockpit. Several other burn pits contained miscellaneous pieces of equipment, including a fuel trailer, various airplane parts, and metal and non-metallic debris of unknown, but presumably of aircraft origin. Firefighter training ceased at UST Site 18 in May 1997 (CH2M HILL, 2003).

### **1.3 OBJECTIVES OF THE STUDY**

Because VOCs in groundwater are present at concentrations exceeding Natural Attenuation Default Source Concentrations (NADSCs), a remedy is required to address residual contamination present at UST Site 18. The contamination has been identified in a series of investigations that are summarized in Section 2.2. Please refer to Appendix F for analytes and concentrations detected in exceedance of FDEP GCTLs and NADSCs. DBB is anticipated to be an effective technology to reduce contaminant concentrations in groundwater and therefore a treatability study will be conducted to aid in preparation of a Remedial Action Plan (RAP).

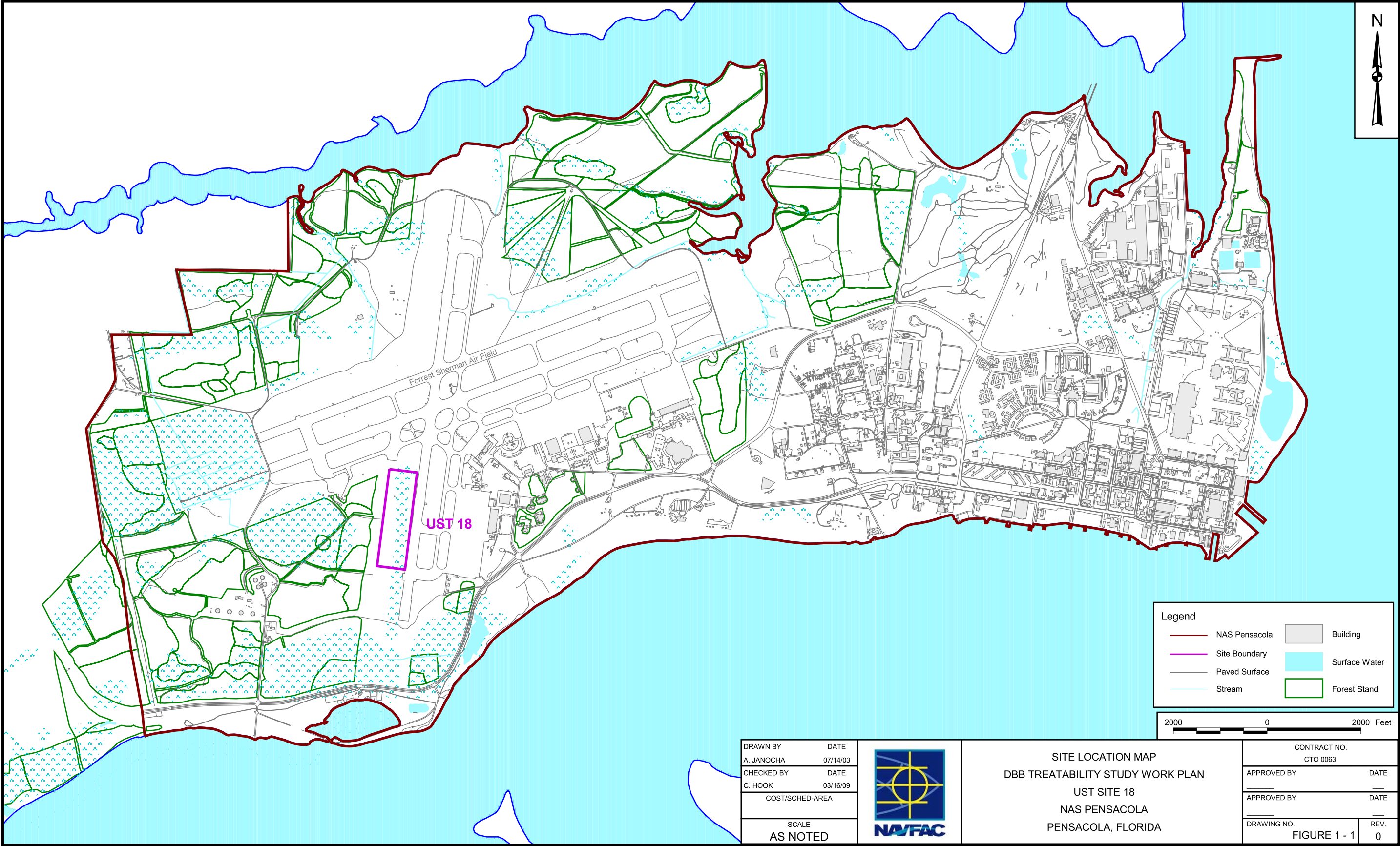
The DBB treatability study addressed by this work plan will be conducted in the northern and southern VOC plumes at UST Site 18 and will include baseline sampling and analysis, Bio-Trap placement and biological analysis, and N-blend nutrient enhancement injection. DBB efficacy will be assessed via biological analysis of Bio-Sep specialized media, which will be enriched with Carbon-13(<sup>13</sup>C)-labeled xylenes as a target contaminant for DBB evaluation. Monitoring of groundwater concentrations of VOCs and other indicator parameters will be conducted to determine the effectiveness of DBB in reducing VOC concentrations in groundwater at the site.

The objective of the treatability study is to assess and compare the effectiveness of in-situ DBB processes via indigenous microbial populations in reducing dissolved-phase VOC concentrations with and without nutrient addition. Data from the treatability study, if applicable, will be used to develop a design basis for site remediation. Xylenes (total) will be the primary target compound for the purposes of this study. The NADSC established for xylenes is 200 micrograms per liter (µg/L).

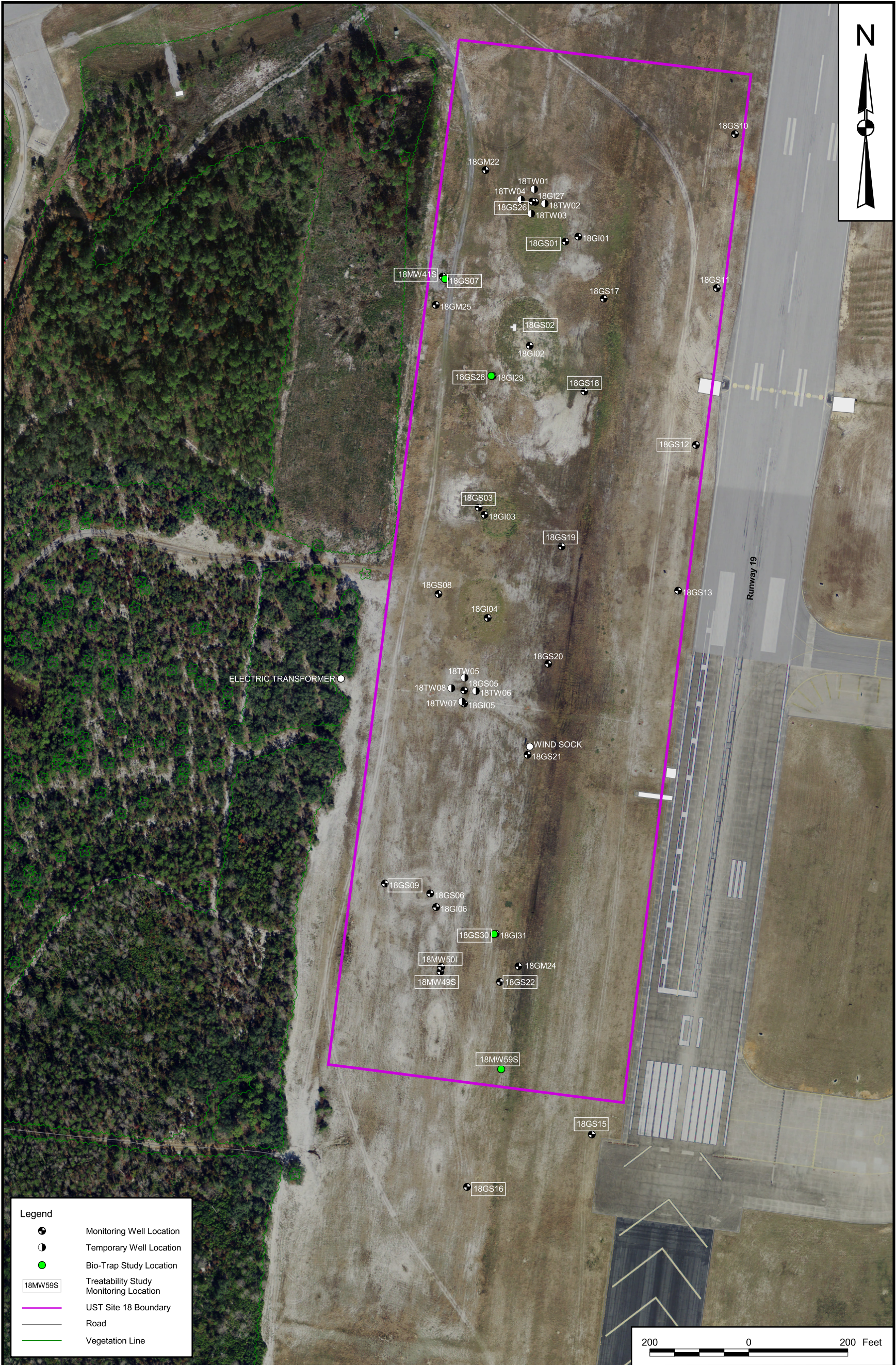
### **1.4 DOCUMENT ORGANIZATION**


This work plan presents the rationale and proposed approach for the treatability study, including a summary of site conditions, the treatability study approach, and details of the treatability study operations and decision processes, in the following sections:

- Section 2.0 - Site Conditions
- Section 3.0 - Treatability Study Summary
- Section 4.0 - Treatability Study Design and Implementation
- Section 5.0 - Sampling and Investigative-Derived Waste Handling







DRAWN BY J. ENGLISH		DATE 02/09/09			SITE MAP DBB TREATABILITY STUDY WORK PLAN UST SITE 18 NAS PENSACOLA PENSACOLA, FLORIDA				CONTRACT NUMBER CTO 0063			
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## **2.0 SITE CONDITIONS**

### **2.1 GEOLOGY AND HYDROGEOLOGY**

A continuous confining unit was documented in the 1996 Contamination Assessment Report (CAR) (EAH, 1996), which identified a lower permeability zone from around 57- to 65-feet below grade surface (bgs). The thickness of the confining unit typically ranged from 8- to 17-feet thick across the base and is assumed to be similar under UST Site 18. The existence of the confining unit at UST Site 18, with a thickness of 2- to 4-feet thick, was verified via a subsequent subsurface investigation (TtNUS, 2006). The unit is absent south of SB-06 and was not present in the southern of the site at soil borings SB-02 and SB03 as shown in SARA Addendum Figure 2-3. In these locations, gray to brown medium sands with silt exist from land surface down to a confining unit at 82 feet bgs.

A deeper confining unit originates at a depth of approximately 82- to 85-feet bgs, comprising of hard, plastic blue-gray clay. The confining unit was observed to a depth of 108 feet bgs, where the deepest soil boring was terminated.

Groundwater contours within shallow, deep, and intermediate aquifers were analyzed within the 2006 Site Assessment Report Addendum (TtNUS, 2006). Groundwater flows southeast within the shallow screened interval (3- to 20-feet bgs). Groundwater flows more to the east and then varies into a southeastern direction toward the southern portion of the site. Groundwater in intermediate (20- to 40-feet bgs) and deep (40+ feet bgs) aquifers similarly flow in a southeastern direction. Groundwater flow is toward the Gulf of Mexico, located approximately one half of a mile southeast of the site.

### **2.2 PREVIOUS INVESTIGATIONS**

#### **CERCLA Investigation**

UST Site 18 was initially investigated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as Installation Restoration (IR) Site 3. Only the presence of petroleum-related constituents was indicated, resulting in the NAS Pensacola Tier 1 Partnering Team transferring the site to the petroleum program in March 1995 (EAH, 1996).

#### **Contamination Assessment**

A CAR was prepared for UST Site 18 in January 1996 by EAH. As part of the CAR, 22 permanent shallow and intermediate groundwater monitoring wells were installed, and soil, sediment, groundwater, and surface water samples were collected and analyzed for petroleum constituents. Contaminants of



concern (COCs) including benzene, toluene, ethylbenzene, and xylenes (BTEX), ethylene dibromide (or 1,2-dibromoethane), naphthalene, and lead were detected (EAH, 1996).

### **Remedial Action Plan**

A RAP was submitted by EnSafe, Inc. for UST Site 18 on December 19, 1997. The RAP proposed using landfarming to remediate soil contamination, thereby removing the source of groundwater contamination. Groundwater modeling indicated that natural attenuation would remediate the groundwater after landfarming was complete. A Monitoring Only Plan was proposed for groundwater remediation (Ensafe, 1997).

### **Soil Remedial Action and Groundwater Monitoring**

CH2M Hill performed landfarming of petroleum-contaminated soil in the four former firefighter training burn pits. Landfarming activities were conducted between September 2000 and September 2001 and consisted of biweekly soil tilling and the collection and analysis of monthly soil and groundwater samples from selected groundwater monitoring wells. The tilling was accomplished using a farm tractor and disk harrow, which turned and aerated the soil to a depth of 6 inches bgs. Light non-aqueous-phase liquid (LNAPL) was detected in monitoring well 18GS05 during the first two monthly monitoring events conducted during landfarming remediation. Landfarming operations ceased in September 2001 when soil analytical results indicated that soil cleanup goals had been achieved (CH2M Hill, 2003).

CH2M Hill performed groundwater monitoring monthly from December 2000 through August 2001 and then quarterly until December 2002 to evaluate whether COC concentrations were decreasing after the remediation of impacted soil and to ensure that point-of-compliance wells were not affected. Concentrations of BTEX, polynuclear aromatic hydrocarbons (PAHs), total recoverable petroleum hydrocarbons (TRPH), and lead were consistently detected in excess of FDEP GCTLs during quarterly sampling. Because groundwater monitoring results indicated that petroleum constituent concentrations were not decreasing at UST Site 18, NAVFAC SE requested that TtNUS perform a treatability study to evaluate PermeOx<sup>®</sup> Plus (an oxygen-releasing compound) for remediation of petroleum hydrocarbons.

### **2003 Supplemental Site Assessment**

Supplemental site assessment activities were performed by TtNUS in August 2003 to further delineate groundwater contamination and to provide a baseline for the Permeox<sup>®</sup> Plus treatability study. The study consisted of a direct-push technology (DPT) investigation and subsequent groundwater sampling and analysis from both selected DPT locations and existing monitoring wells.

Two main areas of contamination were identified during the additional groundwater investigation. A northern plume was identified around the four former pits, and a southern plume was identified south of the four former pits. Both plumes were migrating southeast (with groundwater flow) from their source areas. The aerial extent of contamination for both areas was larger than previously identified by CH2M Hill. In addition, contamination was detected to 50 feet bgs (maximum depth sampled) and was assumed to extend to the confining unit that reportedly occurred between 50 and 60 feet bgs. Details of the additional investigation are provided in the Enhanced Natural Attenuation Treatability Study Work Plan for UST Site 18 (TtNUS, 2003).

### **Treatability Study**

The PermeOx<sup>®</sup> Plus injection event was conducted from December 3 to 17, 2003. This pilot-scale treatability study consisted of the installation of 219 injection borings (143 in the northern plume and 76 in the southern plume) into which a PermeOx<sup>®</sup> Plus enriched slurry was injected. Select groundwater monitoring wells were then monitored for site COCs and natural attenuation parameters for four quarters to evaluate the effectiveness of enhanced bioremediation (TtNUS, 2005).

The conclusions derived from the PermeOx<sup>®</sup> Plus injection provided no clear evidence of a reduction in site COCs after 1-year of monitoring. It was reasoned that contaminated soil exists around the smear zone (underneath the landfarming effort) that continually contributes to groundwater contamination. Post-injection monitoring results indicated that COC concentrations had generally not decreased in the northern and southern area plumes, and concentrations of BTEX, TRPH, and PAHs remained elevated with no clear indication of natural degradation.

### **Site Assessment Addendum Investigation**

In response to the recommendation of the Enhanced Natural Attenuation Study, additional groundwater delineation was conducted as part of a SARA investigation from February to May 2006. The conclusions based on data collected during the SARA investigation are summarized as follows (TtNUS, 2008):

- The low-permeability clay unit previously identified at approximately 60 feet bgs is not believed to be continuous across the entire site. The unit ranges in thickness from 2 to 4 feet and is not present at the southern portion of the site. However, a deeper clay unit at approximately 82 feet bgs is believed to act as an aquitard across the site throughout the entire investigation area.
- General horizontal groundwater flow is across the site toward the south-southeast. A downward vertical groundwater gradient exists at the site.

- LNAPL was present in monitoring well 18-GS26. LNAPL was not detected in any other on-site monitoring wells or in temporary wells installed within 25 feet of monitoring wells 18GS26 and 18GS05.
- Petroleum contaminants including BTEX detected at concentrations greater than FDEP GCTLs are present in groundwater from the water table (approximately 3 feet bgs) to approximately 60 feet bgs. The majority of contamination is present in the shallow groundwater zone from the water table to approximately 20 feet bgs. Contamination was observed in groundwater at approximately 75 feet bgs between the two clay units identified in the northern portion of the site. Contamination of the deeper groundwater flow zone (approximately 62 feet bgs) was not reported in the southern portion of the site, where the upper clay unit is believed to be absent.
- Two separate groundwater plumes were identified at the site. The largest plume is located in the northern and central portions of the site and extends to 60 feet bgs. A smaller plume is located in the southern portion of the site and extends to approximately 40 feet bgs. Both plumes contain contaminant concentrations exceeding FDEP GCTLs and NADSCs according to Chapter 62-777.170, F.A.C. Please refer to Appendix F for organic analytes and concentrations detected in exceedance of FDEP GCTLs and NADSCs.
- Iron and manganese were detected in excess of FDEP GCTLs in most of the shallow, intermediate, and deep groundwater monitoring wells. Please refer to Appendix F for inorganic analytes and concentrations detected in exceedance of FDEP GCTLs and NADSCs.

### **3.0 TREATABILITY STUDY SUMMARY**

This section describes the general methods to be used in conducting the treatability study and provides information on how the data generated will be utilized to develop a remedy to address VOCs above NADSCs. More detailed information on each aspect of the treatability study is provided in Section 4.0.

#### **3.1 TREATABILITY STUDY**

TtNUS will conduct a treatability study in the northern and southern plumes as UST Site 18 to determine if DBB processes are amenable to reducing VOC concentrations below NADSCs, and, if so, the data from the study will provide a basis for implementation of either monitored natural attenuation (MNA) or nutrient-enhanced DBB. The treatability study generally includes baseline groundwater sample collection and Bio-Trap biological sampling and analysis. The study will also include the injection of N-Blend, a nutrient enhancement formulation, into selected test wells to promote DBB within the subsurface. The test wells will be equipped with a "Bio-Trap." Each Bio-Trap will contain a known concentration of xylene. To allow sufficient time for biotic processes to occur, the Bio-Traps will be collected 60 days following test initiation. The data will then be analyzed to determine the rate of degradation via naturally occurring bioremediation and with enhanced bioremediation (nutrient addition), and for the design and implementation of a remediation process, if appropriate.

#### **3.2 TREATMENT GOALS**

The goal for the DBB treatability study is to assess and compare the degradation rates of xylenes within the Bio-Traps placed in the study monitoring wells. Results from two study area wells (one with nutrient injection and one without), in each of the plume areas will be evaluated. The treatment goal, whether through MNA or aquifer amendment, will be to achieve the NADSCs under FDEP regulations for organic COCs (BTEX, PAHs, and TRPH) in the shallow, intermediate, and deep aquifer zones. Following attainment of NADSCs, MNA will be conducted ultimately to achieve FDEP GCTLs for VOCs.

No active treatment is proposed for inorganics (lead, iron, and manganese). Lead concentrations are only slightly greater than its NADSC at one location. Iron and manganese are secondary COCs (non-priority pollutants). Concentrations of inorganics are typically less than NADSCs in the deeper aquifers. Therefore, it is assumed that natural attenuation (physical processes) will eventually reduce the concentrations of inorganics to less than FDEP GCTLs, which can be demonstrated via monitoring.

#### **3.3 EXPANDED REMEDIATION**

If the treatability study results indicate that the intrinsic MNA capacity of the aquifer can achieve NADSCs, MNA may be implemented as a remedy. If the treatability study results indicate that MNA is not a viable

remedial option, and nutrient-enhancement aids in the reduction of COCs to levels that indicate NADSCs may be achieved within a reasonable time frame, full-scale remediation through nutrient addition may be implemented at UST Site 18. This will likely require the installation of a series of borings through which nutrient amendments will be injected. The results of the initial treatability study will be utilized to determine the most effective injection conditions and the mass of nutrients required. Following completion of the remedial implementation, MNA will be used to complete the remedial process.

## 4.0 TREATABILITY STUDY DESIGN AND IMPLEMENTATION

### 4.1 STUDY DESIGN

This section provides details on the design of the treatability study, including technology and location selection, goals of the treatability study, and the analytical parameters for the DBB treatability.

#### 4.1.1 Technology Selection

The following remedial technologies were considered for evaluation at UST Site 18:

- *Air Sparging:* Air sparging is potentially effective for remediation of the site COCs. The injection of air into to an aquifer at higher flow rates typically results in the volatilization of contaminants and subsequent “stripping” of dissolved-phase organic compounds from groundwater. However, the depth to water is very shallow at the site (3 to 4 feet bgs), limiting the possibility of performing soil vapor extraction (SVE) for the capture of VOCs in the vadose zone. In addition, the naturally occurring concentrations of iron and manganese in the groundwater are elevated, particularly in the intermediate zone. The introduction of air into the groundwater would most likely result in significant metals precipitation, which could foul the sparge wells and the pore spaces in the vicinity of the sparge wells. Therefore, air sparging has been eliminated from further consideration.
- *Biosparging:* The installation of low flow (1 to 2 cubic feet per minute) air sparge wells throughout the VOC plumes could result in the stimulation of aerobic biological activity and a subsequent reduction of contaminant concentrations. The oxygen in the supplied air would also be consumed through chemical processes such as the oxidation of metals. This is a concern at the site considering the elevated concentrations of iron, particularly in the intermediate zone. Based on data from previous sampling events, the aquifer conditions indicate that anaerobic processes may be occurring within the contaminant plumes; therefore, it may not be prudent or cost-effective to reverse the existing degradation pathways. However, for evaluation purposes, there are two approaches to consider for the biosparge design.

The first approach is the delivery of air throughout the entire plume area using nested sparge wells covering depths from 3 feet to 60 feet bgs. Assuming a 15-foot radius of influence for each sparge well, it is estimated that a total of 250 biosparge wells would be required in the northern plume area and an additional 115 biosparge wells would be required in the southern plume area. The system operational period to achieve NADSCs is estimated to be about 3 to 4 years.

The second approach is the delivery of air through strategically placed bio-curtains. This approach would greatly reduce the number of sparge wells installed in the plumes. The wells would be installed across the areas of highest contaminant concentrations and greatest plume thickness. Nested wells would be installed as required to address contaminant concentrations at various depths. It is estimated that a total of 25 sparge wells would be installed in the northern plume, and 15 sparge wells would be installed in the southern plume. Residual dissolved oxygen (DO) would migrate downgradient, enhancing the biological activity in other areas of the plume. It was estimated that this system would require 5 to 6 years to achieve NADSCs.

- *Enhanced Anaerobic Biodegradation:* The addition of nitrate, nitrite, ammonium, orthophosphate and complex phosphate to the groundwater beneath the site to enhance anaerobic degradation of COCs through denitrification appears to be a viable remedial alternative. Nitrate is a highly soluble compound that acts as both a nitrogen-source nutrient and an electron acceptor. This combination promotes anaerobic biodegradation and chemical oxidation of organic compounds, which would compliment the reducing conditions that exist within the contaminant plumes at the site. Field data collected during groundwater sampling indicates the dissolved oxygen within the plume footprint has been depleted. Bacteria such as Betaproteobacteria and Gammaproteobacteria use nitrate to respire under such conditions.
- *Monitored Natural Attenuation:* The fourth potential remedial approach is completion of a fate and transport or scientific "evaluation" as required in 62-780.790(1), F.A.C. to request permission to remediate the site through MNA only. In this case, the plume should no longer be migrating and natural degradation processes are occurring at the site that do not require enhancement. It is anticipated that the site use would remain unchanged for many years and that restrictions can be applied to future land use. Additionally, there are no potential receptors in the vicinity of the site. Costs for this approach would be significantly less than the other remedial options.

Based on the evaluation summarized above, both MNA and enhanced anaerobic bioremediation of petroleum hydrocarbons are considered viable technologies.

Although DBB is considered a viable option for this site, there are several factors that raise concerns regarding its capability to meet the NADSCs, including:

- Adsorbed-phase hydrocarbons may be a continuing source of groundwater contamination, and the focus of the treatability study is only dissolved-phase hydrocarbons.
- The site contains a substantial volume of unconfined saturated soil extending to approximately 60 feet bgs. Possibly, large quantities of nutrient enhancements may be required to contact and treat the large volume of saturated soil and groundwater above NADSCs.

#### **4.1.2      Location Selection**

Following the selection of the treatability test technology, the size and location of the study were considered. Because the majority of groundwater VOC contamination was identified in the shallow aquifer, the study area is limited to the shallow aquifer to confine the vertical extent of the study boundary. Based on previous site sampling results, monitoring wells with the highest total VOC levels were selected as DBB study wells. Baseline sampling will be conducted in monitoring wells within and along the perimeter of the northern and southern plumes as shown in Figure 4-1. This area is located east of Runway 19. Specifically, the study locations were selected for the following reasons:

- The northern and southern plume VOC groundwater concentrations are among the highest on the site for VOCs.
- The area is open and has relatively few utilities that may interfere with injection activities.
- Existing monitoring wells in the vicinity of the study area can provide data directly upgradient and downgradient of the study area.

Since samples will be collected from areas most likely to be contaminated, the biased selection of sample locations does not support the use of quantitative statistics to estimate decision performance. Instead, the Project Team will use the results of the investigation to determine whether the amount and type of data collected is sufficient to support the attainment of project objectives. This will involve an evaluation of biological parameters and contaminant concentrations to ensure that the results are likely to have been positively detected (if present) and that enough data have been collected to support the treatability study conclusions.

#### **4.1.3      Bio-Trap Sampler**

This section describes the design basis for using Bio-Trap samplers for the evaluation of DBB of VOCs in groundwater at the site. Bio-Trap samplers are used as a tool to collect microbial biomass from in-situ environments. Each sampler is filled with Bio-Sep bead media, which is comprised of 75-percent powdered activated carbon and 25% Nomex. The composite construction allows for a very high surface



area (600 square meters per gram), allowing for optimal microbial exposure to the Bio-Sep media. Bio-Trap details from the supplier are provided in Appendix A.

Bio-Sep beads in the Bio-Trap samplers proposed for the treatability study are enriched with  $^{13}\text{C}$ -labeled xylene as a target contaminant for microbial degradation and molecular tracer for stable isotope probing (SIP). A determination of xylene degradation rates will be made via measurements of  $^{13}\text{C}$ -labeled xylenes concentrations within the Bio-Sep media prior to and following incubation of the Bio-Trap samplers. In addition, microbial analysis of  $^{13}\text{C}$  microbial biomarkers can provide proof of contaminant degradation and information regarding microbial mechanisms occurring throughout the hydrocarbon degradation process.

Two Bio-Trap samplers will be placed in both the northern and southern plume areas in existing monitoring wells. A Bio-Trap will be placed in each plume to evaluate MNA within the VOC plumes. A second Bio-Trap will be placed in each plume and enhanced with N-blend (nutrients) to evaluate the performance of enhanced DBB. For the northern plume, 18GS07 will be used as a DBB Bio-Trap sampling location and 18GS28 will be used as an N-Blend enhanced DBB Bio-Trap sampling location. For the southern plume, 18GS30 will be used as a DBB Bio-Trap sampling location, and 18MW59S will be used as an N-Blend enhanced DBB Bio-Trap sampling location.

#### **4.1.4      N-Blend Amendment Injection**

N-Blend is a nutrient substrate formulation designed to provide optimal subsurface conditions for DBB and consists of a concentrated solution of nitrate salts, complex phosphates, wetting and chelating agents, and micronutrients. N-Blend enhancement will occur in Bio-Trap sampling locations at treatability study wells 18GS28 and 18MW59S. A total of 260 gallons will be injected under low-flow/pressure at the two locations. N-Blend details from the supplier are provided in Appendices A and D. Please note that Appendix D contains N-Blend manufacturer confidential information and is submitted as a separate attachment.

##### **4.1.4.1      Regulatory Conditions for N-Blend Injection**

N-Blend product is not on a list of the FDEP approved products or technologies for use in remediation. However, in accordance with the July 2007 letter from FDEP to Manufacturers, Vendors and Interested Parties regarding the Innovative Technology Program for Petroleum Remediation, prior approval is not required for a petroleum remediation product in order to propose it in a site specific Remedial Action Plan (RAP). This statement assumes that such a plan includes all appropriate details regarding the composition of the product and its use for remediation. As required by the FDEP July 20, 2007 letter a detailed chemical composition of N-Blend product is presented in Appendix D (manufacturer confidential

information). However, in accordance with the FDEP letter it has been submitted as confidential information under a separate cover and is not to be available in the public record.

A comparison of the N-Blend composition and the Florida Drinking Water Standards (Chapter 62-550 Drinking Water Standards, Monitoring, and Reporting) indicated that the concentration of nitrates in N-Blend exceeds Florida primary drinking water standard (10 mg/L as total N) and the concentration of total dissolved solids in N-Blend exceeds Florida secondary drinking water standard (500 mg/L). However, it is expected that following the injection, the downstream concentrations of nitrates and total dissolved solids (TDS) will quickly decrease due to consumption of nitrate salts by microorganisms and also due to dispersion and dilution. A simplified estimate (Appendix D) based on assumed dilution/dispersion of the injected N-Blend and basic aquifer parameters indicates that nitrates and TDS concentration should decrease below Florida primary and secondary drinking water standards (10 mg/L as total N for nitrates and 500 mg/L for TDS) within approximately 120 feet downstream of the injection point in approximately 1 year. Note that due to existing anaerobic conditions in the subsurface beneath UST Site 18, an additional significant decrease due to consumption of nitrates by microorganisms is expected. Although this estimate is an approximation it is believed to be a conservative estimate. Furthermore, total area of impact is well within the site and contamination extent and there are no receptors or exposure pathways within this zone.

However, based on the requirements of Underground Injection Control Section (Florida Bureau of Water Facilities Regulation), a memorandum to Underground Injection Control Section (UIC) that describes injection details and establishes a temporary zone of discharge (ZOD) is required. Specifically, a ZOD permission by paragraph 62-522.300(2)(c), F.A.C. applies in this case because nitrates are prime constituents of the N-Blend reagents used to remediate the site contaminants. Please refer to the attached UIC memorandum in Appendix E for details.

#### **4.1.5 Groundwater Monitoring**

Groundwater monitoring at the site will be conducted to establish baseline conditions prior to implementation of the treatability study. This will include sampling of the four study wells and additional monitoring wells within the plumes and along the perimeter of each plume. Monitoring well locations used for this study are shown on Figure 4-1.

Prior to and following completion of the treatability test, the four study wells will be sampled for biological and chemical parameters.

Contaminant concentration data for BTEX, PAHs, and TRPH in groundwater will be compared to NADSCs and background concentrations. Laboratory quantitation limits for the proposed analytical methods should not exceed FDEP GCTLs.

## **4.2 STUDY IMPLEMENTATION**

This section describes the implementation of the treatability study in detail, including baseline sampling, Bio-Trap sampler placement, N-Blend nutrient injection, post-study sampling, and reporting.

### **4.2.1 Baseline Sampling**

To determine groundwater conditions at the site, one round of baseline groundwater sampling will be conducted for the parameters indicated in Table 4-1 at the monitoring wells specified on Figure 4-1. The results from baseline sampling will also be used to verify Bio-Trap placement. New study locations will be selected should the data indicate the pre-selected locations are longer the most appropriate. The analysis of groundwater samples will include both field parameters and laboratory analysis as detailed in Table 4-1 and as follows:

- Collection of field parameters, including dissolved carbon dioxide, conductivity, DO, oxidation/reduction potential (ORP), pH, temperature, and turbidity in 10 monitoring wells.
- Collection of up to 20 groundwater samples for analysis of BTEX (USEPA SW-846 Method 8260B), PAHs (USEPA SW-846 Method 8310), and TRPH via Florida Petroleum-Range Organics (FL-PRO) Method in 20 site monitoring wells

In addition to the above parameters, samples from treatability study wells 18GS07, 18GS28, 18GS30, and 18MW59S will be analyzed for ferrous iron, ammonium, complex phosphate, microbial cell count, nitrate, nitrite, orthophosphate, sulfate, and methane.

The sampling design consists of two separate plume areas that contain the footprint of areas impacted by VOCs within shallow monitoring wells. The field-sampling program will focus on characterizing subsurface geochemical, contaminant, and biological parameters within the areas of concern. The samples will be collected within the plumes to ensure that the decision units are represented spatially. The significance and use of the data for each parameter is summarized in Table 4-2. Information on groundwater sampling procedures is included in Section 5.0.

### **4.2.2 Bio-Trap Sampler Placement**

Bio-Trap samplers will be received on blue ice and will remain ice cooled until deployment. The samplers will not be stored for a period greater than 2-weeks prior to deployment. Prior to installation, a minimum of three well volumes will be purged from each study well. The sampler will be removed from the zippered bag and attached to a nylon attachment loop and nylon line. Next, the sampler will be placed in

the monitoring well at the depth where elevated contaminant concentrations exist (typically 1 to 1.5 feet below the water table).

#### **4.2.3 N-Blend Nutrient Injection**

One N-Blend nutrient injection event will be performed in the treatability study based on the design considerations detailed above. Injections will be conducted sequentially in treatability study wells 18GS28 and 18MW59S. At that time, N-Blend will be dispersed into the formation. A pulsing interval will continue for 15 to 20 minutes, depending on the achievable flow rate until the desired quantity has been injected.

During injection operations, the following parameters will be monitored to confirm the safety and effectiveness of the process, as well as to provide data to be used for adjustment/optimization throughout the process. The monitoring includes:

- VOC vapors in the breathing zone utilizing a photoionization detector (PID). If unacceptable concentrations are observed, field personnel will be properly protected, and the injection procedures will be modified as necessary to mitigate the vapors. Potential measures that could be implemented include sealing nearby wells to minimize venting of vapors, reducing the injection rate, and pulsing the injection.
- Injection flow rate and volume of N-Blend at each location and interval will be monitored. The period of injection at each interval will be adjusted based on these flowrates and volumes.

#### **4.2.4 Post-Study Sampling**

Sixty days after nutrient injection, Bio-Trap samplers will be removed and analyzed at a fixed-base laboratory. The samplers will be placed in labeled zippered bags, double bagged within a larger zippered bag, and immediately placed on blue ice in a cooler. Each of the samplers in the four treatability study wells will be analyzed for xylene-specific stable isotopes within <sup>13</sup>C-labeled phospholipid-fatty acids (PLFAs), qPCF assays (such as nirS, nirK, and benzyl succinate synthase), and other related biodegradation indicators. These parameters will provide insight into the degradation mechanisms occurring at the site and give an indication of the potential for DBB to reduce VOC concentrations to less than NADSCs with or without nutrient enhancement. Details on the significance and use of these parameters in evaluating the treatability study are presented in Table 4-2. More specific information on groundwater sampling procedures is included in Section 5.0.

### **4.3 ANALYTICAL APPROACH**

Following receipt of treatability study data, the following decision rules will be used as a weight-of-evidence for determining the applicability of DBB for full-scale remedial design and implementation

1. If baseline sampling data vary significantly in concentration and location from historical data, then an alternate treatability study approach may be necessary.
2. If individual well baseline concentrations of BTEX, PAHs, and TRPH are all less than NADSCs, then monitored natural attenuation may be considered.
3. If the results from baseline groundwater monitoring suggest aerobic subsurface conditions, then additional testing may be conducted and/or re-evaluation of the treatability study approach considered.
4. If treatability study results indicate VOCs can meet NADSCs via natural attenuation, MNA will be considered as a remedy for UST Site 18.
5. If treatability study results indicate aquifer nutrient enhancement is favorable over naturally occurring attenuation processes, then DBB via aquifer nutrient enhancement, will be considered as a remedy for UST Site 18.

### **4.4 REPORTING**

Results, conclusions, and recommendations from the treatability study will be presented in a RAP Addendum. The report will include a conceptual design for full-scale remediation, including a basis of design utilizing the data from the treatability test, if appropriate, based on analysis of the potential of this technology to reach overall site remedial goals.



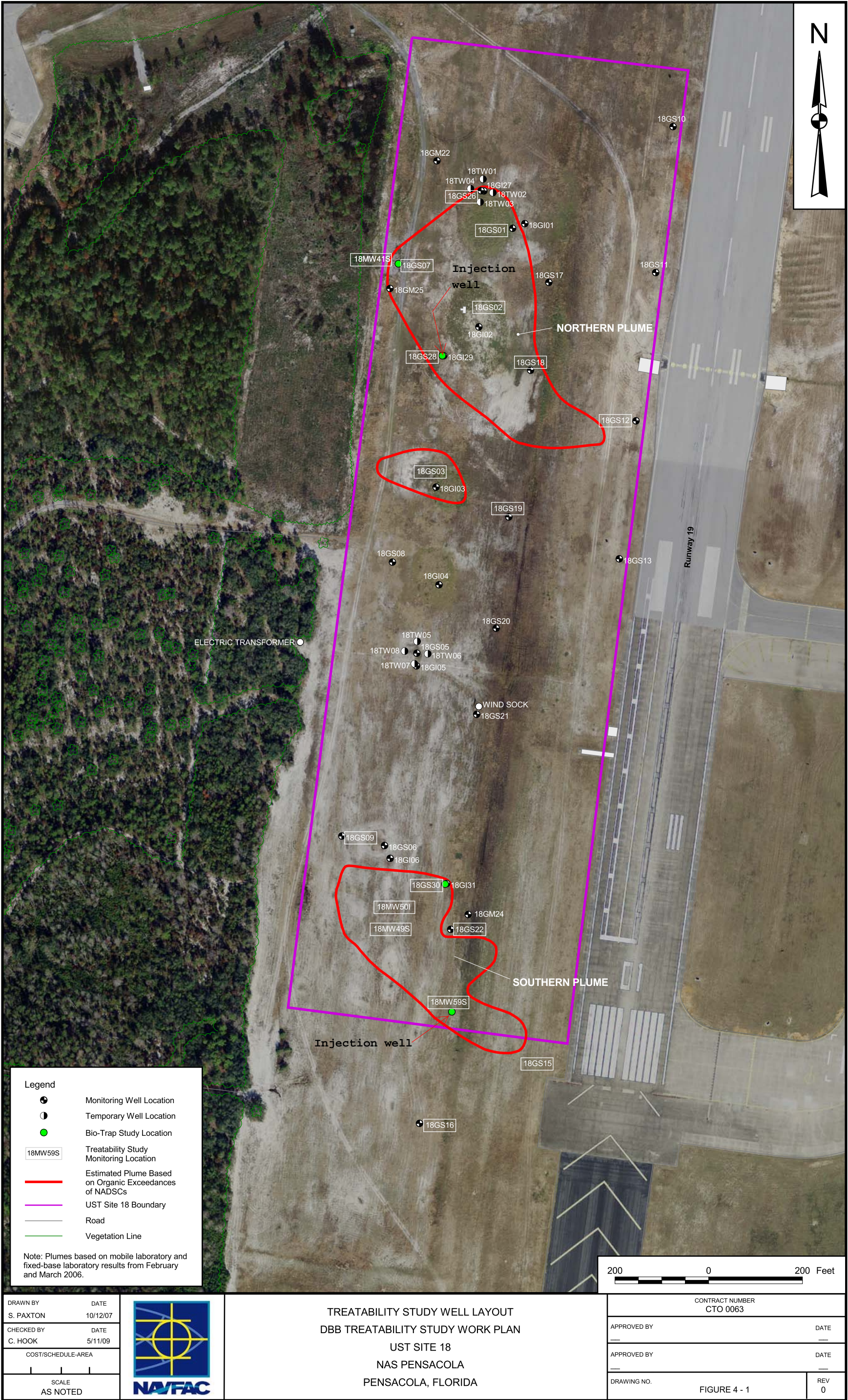




TABLE 4-1

**SAMPLING AND ANALYSIS SUMMARY**  
**DENITRIFICATION-BASED BIODEGRADATION PILOT STUDY WORK PLAN**  
**UST SITE 18**  
**NAS PENSACOLA**  
**PENSACOLA, FLORIDA**

Location		LABORATORY PARAMETERS												FIELD TESTS							Aquifer Zone and Location	
		BTEX	PAHs	TRPH	Methane	Ammonium	Ferrous Iron	Nitrate	Nitrite	Complex Phosphate	Orthophosphate	Sulfate	Microbial Cell Count	Bio-trap Biological Analysis	pH	Temperature	Dissolved Oxygen	Dissolved Carbon Dioxide	Oxidation/Reduction Potential	Conductivity		Turbidity
Northern Plume Area	18GS01	✓	✓	✓																		Shallow, northern plume
	18GS02	✓	✓	✓											✓	✓	✓	✓	✓	✓	✓	Shallow, northern plume
	18GS03	✓	✓	✓																		Shallow, isolated detection
	18GS07	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Shallow, northern plume, bio-trap location
	18GS12	✓	✓	✓																		Shallow, downgradient of northern plume
	18GS17	✓	✓	✓											✓	✓	✓	✓	✓	✓	✓	Shallow, northern plume
	18GS18	✓	✓	✓											✓	✓	✓	✓	✓	✓	✓	Shallow, northern plume
	18GS19	✓	✓	✓																		Shallow, downgradient of northern plume
	18GS26	✓	✓	✓																		Shallow, northern plume
	18GS28	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Shallow, northern plume, enhanced bio-trap location
Southern Plume Area	18MW41S	✓	✓	✓																		Shallow, northern plume
	18GS06	✓	✓	✓											✓	✓	✓	✓	✓	✓	✓	Shallow, upgradient of southern plume, bio-trap control location
	18GS09	✓	✓	✓																		Shallow, up-gradient of southern plume
	18GS15	✓	✓	✓																		Shallow, downgradient of southern plume
	18GS16	✓	✓	✓																		Shallow, downgradient of southern plume
	18GS22	✓	✓	✓											✓	✓	✓	✓	✓	✓	✓	Shallow, sidegradient of southern plume
	18GS30	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Shallow, southern plume, bio-trap location
	18MW49S	✓	✓	✓											✓	✓	✓	✓	✓	✓	✓	Shallow, southern plume
	18MW50I	✓	✓	✓																		Intermediate, southern plume
	18MW59S	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Shallow, southern plume, enhanced bio-trap location

BTEX - Benzene, toluene, ethylbenzene, and xylenes (total)

PAHs - Polynuclear aromatic hydrocarbons

TRPH - Total recoverable petroleum hydrocarbons

Bio-Trap Biological Analysis - includes phospholipid fatty acids and qPCR analyses.

✓ - Denotes selected analysis

TABLE 4-2

**SUMMARY OF DATA USES FOR ANALYTICAL PARAMETERS  
DENITRIFICATION-BASED BIODEGRADATION PILOT STUDY WORK PLAN  
UST SITE 18  
NAS PENSACOLA  
PENSACOLA, FLORIDA**

Parameter	Use of Data
<i>Laboratory Analysis:</i>	
<sup>13</sup> C Xylenes	Determines the quantity of <sup>13</sup> C xylenes remineralized versus incorporated into biomass
Ammonium	Potential substrate for microbial respiration.
Nitrate	Potential substrate for microbial respiration. May compete as an electron acceptor if present at moderate concentrations (>1 mg/L).
Nitrite	The reduced species of nitrogen. Provides additional information on microbial and geochemical conditions.
Orthophosphate/Complex Phosphate	Potential substrate for microbial respiration. Provides additional information on microbial and geochemical conditions.
Bio-trap Biological Analysis	Indicates the mechanisms whereby reduction of contaminants has been accomplished. Data can be utilized to confirm that contaminant destruction is taking place (as opposed to reduction of concentrations via dilution or migration).
Microbial Cell Count	Direct numerical counts of total microbial cells. Determines overall flux of microbial populations.
Phospholipid-Fatty Acids	Formed through the breakdown of organic substrates; indicates the presence of an environment conducive to biodegradation.
<i>Field Analysis:</i>	
Temperature	Biological processes are temperature dependent.
pH	Biological processes are pH sensitive.
Conductivity	General water quality parameter used to verify that site samples are obtained from the same groundwater system.
Dissolved oxygen	Concentrations of less than 1 mg/L indicate anaerobic conditions in the aquifer.
Dissolved carbon dioxide	Indicator of biological oxidation of VOCs.
ORP	Provides information on aquifer conditions; >+200 mV generally indicates aerobic conditions, <-200 mV generally indicates anaerobic, reducing conditions.

Bio-trap Biological Analysis - includes phospholipid fatty acid and qPCR analyses.

ORP - Oxidation/reduction potential

mg/L - Milligram per liter

mV - Millivolts



## **5.0 SAMPLING AND IDW HANDLING PROCEDURES**

### **5.1 SAMPLING PROCEDURES**

This section details the field sampling procedures to be used for the collection of UST Site 18 treatability study samples.

#### **5.1.1 Groundwater Sampling**

Groundwater samples will be collected using the low-flow purge and sampling method; additional guidance is provided in TtNUS Standard Operating Procedure (SOP) SA-1.1 included in Appendix B. In addition, all relevant FDEP SOPs in Chapter 62-160, F.A.C will be followed, including:

- Field Decontamination – FC1000,
- Documentation – FD1000,
- Quality Control – FQ1000,
- General Water Sampling – FS2000,
- Groundwater Sampling – FS2200,
- Biological Communities – FS7000,
- Field Testing General – FS1000,
- Field Testing, parameter specific – FT1100 through 1600,
- Laboratory Documentation – LD1000, and
- Laboratory Quality Control – LQ1000.

The following parameters will be measured during the purging process: temperature, pH, specific conductivity, ORP, turbidity and DO. A peristaltic pump with 1/4-inch Teflon tubing will be used for well purging and groundwater sample collection. Containers for VOC and other analyses will be filled directly from the discharge tubing with the pump cycle reduced to its lowest setting to minimize volatilization of the chemicals. Field parameters will be collected as summarized in Table 4-1. The groundwater samples to be submitted for laboratory analysis will be immediately labeled and placed on ice in an insulated cooler awaiting packing and shipment.

#### **5.1.2 Quality Assurance / Quality Control Samples**

To ensure that data obtained during the investigation are accurate, various quality assurance (QA)/quality control (QC) requirements have been established for fieldwork, laboratory analysis of the collected samples, and validation of the analytical results obtained from the laboratory.

Field QC samples to be collected during the treatability study include consist of field duplicates, field blanks, and equipment (rinsate) blanks. Each of these types of field QC samples will undergo the same preservation, analysis, and reporting procedures as the related environmental samples. The frequency and type of field QA/QC samples to be collected for this investigation is as follows.

Type of Sample	Collection Frequency
Field Duplicate	1 per 10 samples per medium (10 percent)
Field Blank	1 per source per sample event
Equipment Rinsate Blank	1 per 20 per sampling equipment (5 percent)

Laboratory QC requirements not included herein are outlined in detail during the procurement process. It is necessary to collect additional sample volumes for laboratory matrix spike (MS) and matrix spike duplicate (MSC) samples, three times the volume for aqueous samples. One MS/MSD will be analyzed for every 20 or fewer investigative samples collected per media.

### **5.1.3 IDW Samples**

Composite (one aliquot from each drum generated) samples will be collected from the investigative-derived waste (IDW) generated during groundwater sampling to classify the material for disposal. The samples will be submitted to the laboratory for VOC, TRPH, reactivity, corrosivity, and ignitability analyses.

## **5.2 SAMPLE HANDLING**

This section details sample-handling procedures including field-related considerations concerning sample identification, packaging, and shipping. Additional guidance for sample field documentation, packaging, and shipping is provided in TtNUS SOPs SA-6.1 and SA-6.3 provided in Appendix B.

### **5.2.1 Field Documentation**

Field documentation will be conducted as described in TtNUS SOP SA-6.1. Completed chain-of-custody forms will be faxed to the TtNUS Project Manager on a daily basis. Example field data collection sheets are provided in Appendix C.

### **5.2.2 Sample Nomenclature**

Each sample will be assigned a unique codified sample identification number. The labeling system established for this sampling event is based on the following:

1		2		3		4
<u>AAA-NN</u>	-	<u>AA</u>	-	<u>NNN</u>	-	<u>NN</u>
Site Location and Site Number		Medium		Sample Location		Sample Depth or Sampling Round

- 1 PEN- NAS Pensacola, followed by  
18 – UST Site 18
- 2 GW – Groundwater  
BT – Bio-Trap  
FB - Field Blank  
RB - Rinsate Blank  
WB - Source Water Blank  
IDW - IDW  
DU - Duplicate
- 3 An ascending sequential number of samples collected or well number
- 4 Sampling round

The following contains specific nomenclature to be used in this program.

#### **Groundwater Samples**

1		2		3		4
<u>PEN-18</u>	-	<u>GW</u>	-	<u>XXX</u>	-	<u>NN</u>
Site Location and Site Number		Medium		Well Number, excluding "MW")		Sampling Round

- 3 Well number and depth suffix, excluding MW.
- 4 Sampling round in this program, starting at 01.

For example, the first sample from monitoring well 18GS07 at UST Site 18 would be NAS-18-GW-07-01.

#### **Blanks, IDW Sample, and Duplicates**

1		2		3		4
<u>PEN-18</u>	-	<u>MM</u>	-	<u>XXXXXX</u>	-	<u>NN</u>
Site Location and Site Number		Sample Type		Date		Identifier

- 2 Sample type, as noted at the beginning of this subsection.
- 3 Date of sample in the format MMDDYY.
- 4 An ascending sequential number, to differentiate samples collected on the same date, starting at 01.

For example, the sample from IDW generated at UST Site 18 collected on July 15, 2009 would be numbered PEN-18-IDW-071509-01.

Any other pertinent information regarding sample identification will be recorded in the field logbooks and on the sample log sheets.

Field duplicate samples will be reported blind to the laboratory. The time designated on the sample label and chain-of-custody form will be 0000 hours. The location at which each duplicate is collected will be noted on the sample log sheet and in the field notebook. Additional guidance is provided in the TtNUS SOP CT-04 (Appendix B).

### **5.2.3      Sample Packaging and Shipping**

Samples will be packaged and shipped in accordance with the TtNUS SOP SA 6.1 and the following procedures:

- Complete the sample labels and place samples into ZipLoc® (or equivalent) polyethylene bags and seal.
- Place samples into a strong outside container, such as a metal or plastic picnic cooler lined with a polyethylene garbage bag.
- Place absorbent cushioning material around sample (optional).
- Place ice in the cooler on top, bottom, and sides of the sample containers.
- Seal the plastic liner inside the cooler with tape (goose-neck and tape to prevent leaking).
- Place a copy of the chain-of-custody form in a ZipLoc® (or equivalent) bag and tape it to the inside lid of the cooler.
- Apply strapping tape around the outside of the coolers; apply chain-of-custody labels to the cooler cover the seal once with the strapping tape.
- Complete a shipping document and place it on top of the cooler or on the handle for delivery to the overnight courier.
- Bio-Trap and biological samples will be shipped on blue ice for next day delivery.

### **5.3 SAMPLE CUSTODY**

Custody of samples must be maintained and documented at all times. Chain of custody begins with the collection of the samples in the field. A chain-of-custody form provided by the subcontracted laboratory will be used during the sample-handling process. Additional guidance is provided in the TtNUS SOP SA-6.3 (Appendix B).

The chain-of-custody process begins with the collection of samples in the field and ends with sample disposal by the laboratory. TtNUS SOP SA-6.1 (Appendix B) further details chain-of-custody procedures and outline the procedures to be followed when completing the chain-of-custody record.

After sampling, each sample will be maintained in the sampler's custody until formally transferred to another party. A sample is considered to be under custody if:

- The sample is in the physical possession of an authorized person.
- The sample is in the authorized person's view after being in possession.
- The sample was in the authorized person's possession and kept in a locked location to prevent tampering.
- The sample is in a designated secure area, restricted to authorized personnel only.

### **5.4 INVESTIGATION-DERIVED WASTE HANDLING**

The IDW that will be generated during this study includes development and purge water, decontamination fluids, personal protective equipment (PPE), and miscellaneous trash. The Department of Transportation (DOT)-approved 55-gallon drums filled with IDW will be labeled (source, date, medium, and company name) and will be stored in a centralized location for subsequent disposal.

#### **5.4.1 Development and Purge Water**

The development and purge water will be containerized in DOT-approved 55-gallon drums separately from solid materials for subsequent disposal.

#### **5.4.2 Decontamination Fluids**

Fluids generated during the decontamination of sampling equipment will be disposed in the same manner as described for development and purge water.

#### **5.4.3      Personal Protection Equipment and Miscellaneous Trash**

PPE and any miscellaneous trash (i.e., paper towels, nitrile gloves, etc.) will be disposed in an NAS Pensacola trash receptacle.

## REFERENCES

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## **APPENDIX A**

### **TREATABILITY STUDY AMENDMENT AND SAMPLER SPECIFICATIONS**



## Bio-Trap Sampler Protocol

## Stable Isotope Probing

### Handling:

Bio-Trap samplers used for Stable Isotope Probing (SIP) are baited with  $^{13}\text{C}$ -labeled contaminant of interest (e.g. benzene, MTBE, chlorobenzene) adsorbed onto the powder activated carbon (PAC). Controlled laboratory conditions show only minimal loss of contaminant due to volatilization. However, special considerations must be taken into account when handling SIP Bio-Trap samplers in order to reduce risk of volatilization. SIP Bio-Trap samplers are shipped out chilled, on blue ice, and it is *essential* that they should be kept cool until deployment. A trip blank SIP Bio-Trap sampler is included in order to measure any loss due to volatilization prior to deployment. This blank should be kept with the other samplers until they are deployed in the field. At that time the trip blank should be shipped to us, on ice, so that we can measure any loss of contaminant due to volatilization.

When retrieving the Bio-Trap samplers that have been deployed in the field, they should immediately be placed on ice and shipped on ice for next day delivery. These steps will ensure the most accurate results.

Although the contaminant is absorbed onto the beads, caution should be used in handling these Bio-Trap samplers because the contaminant compounds are associated with possible health and safety risks. We provide the appropriate MSDS when shipping SIP Bio-Trap samplers, which can be consulted as needed.

**Note:** Clean sterile gloves should be used at all times when handling Bio-Trap Samplers.

### Storage:

It is important to minimize the amount of time that Bio-Trap Samplers are stored prior to being installed in the field. The physical properties of the Bio-Trap Samplers that make them an ideal medium for collecting microbes also increase the chances of microbial or chemical contamination. Bio-Trap Samplers need to remain sealed and refrigerated (not frozen) until they can be installed in the field. As mentioned above, a trip blank is included in order to measure any loss of contaminant during storage and handling. If the Bio-Trap Samplers are stored for an extended time (more than two weeks), drying could occur, which may then require a longer incubation time in the well.

### Installing Bio-Trap Samplers:

- Prior to installing the Bio-Trap Samplers, the monitoring well may need to be purged if it has not been sampled in a while. If purging is necessary, MI recommends that three well volumes be removed to ensure contact with formation water and reduce well bore effect.
- Remove the Bio-Trap Sampler from the zippered bag and attach the nylon attachment loop (provided) to a nylon line (not provided) and suspend the Bio-Trap Sampler at a depth where significant contaminant concentrations exist. If no data are available on the vertical distribution of contaminants, then suspend the Bio-Trap Sampler in the middle of the saturated screened interval for chlorinated hydrocarbons. For petroleum hydrocarbons, suspend the Bio-Trap Sampler about 1-1.5 ft below the top of the water table. If large fluctuations in the water level are anticipated during the period of incubation, the Bio-Trap Sampler should be suspended from a float (contact MI for further details).
- Once installed, incubation times can vary depending upon the project.

### Removing Bio-Trap Samplers after incubation:

- Open the monitoring well and pull up the Bio-Trap Samplers. Cut and remove the nylon line used to suspend the Bio-Trap Samplers.
- Transfer the recovered Bio-Trap Samplers to labeled (well number and date) zippered bags, seal, then double bag in a larger (one-gallon) zippered bag, and immediately place on blue ice in a cooler.
- Repeat the above for all Bio-Trap Samplers from the site. Individual zippered bags containing the Bio-Trap Samplers can be placed in the same one-gallon zippered bag (if there is enough space).
- A chain of custody (COC) form must be included with each shipment of samples. Access our COC at [www.microbe.com/Chain\\_of\\_Custody.pdf](http://www.microbe.com/Chain_of_Custody.pdf)

### Shipment:

Bio-Trap Samplers need to be shipped on ice (or blue ice) for next day delivery (*please call to confirm Saturday delivery*). If regular ice is used, the ice should be double bagged.

*Samples should be shipped to:*

Sample Custodian  
Microbial Insights, Inc.  
2340 Stock Creek Blvd.  
Rockford, TN 37853-3044  
(865) 573-8188

### Saturday Delivery:

Due to the short hold time associated with RNA it is not recommended to send samples for Q-Expression (RNA) for Saturday delivery.

# mi BIO-TRAP®

ADVANCED DIAGNOSTIC SAMPLERS

*Catch Remediation in the Act... Trap It!*

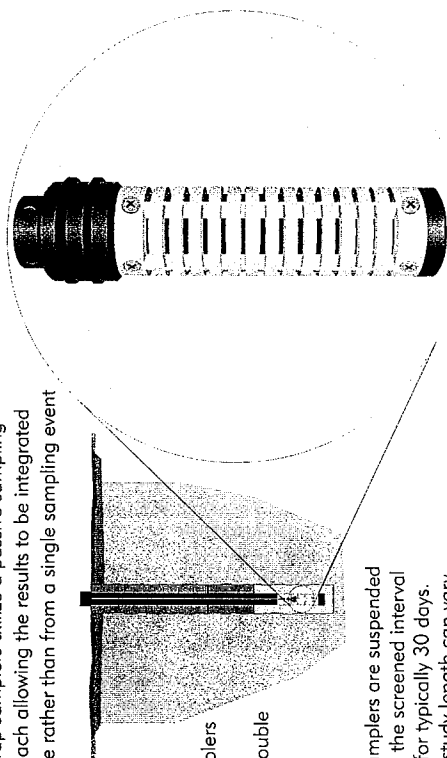
## What are Bio-Trap® Samplers?

Bio-Trap® Samplers are passive sampling tools that collect microbes over time for the purpose of better understanding biodegradation potential. The key to the Bio-Trap® approach is a unique sampling matrix, Bio-Sep® beads. The beads are 2-3 mm in diameter and are engineered from a composite of Nomex® and powdered activated carbon (PAC). When a Bio-Trap® Sampler is deployed in a monitoring well, the Bio-Sep® beads adsorb contaminants and nutrients present in the aquifer essentially becoming an *in situ* microcosm with an incredibly large surface area (~600 m<sup>2</sup>/g) which is colonized by subsurface microorganisms. Once recovered from a monitoring well (30-60 days after deployment), DNA, RNA, or PLFA can be extracted from the beads for CENSUS® or PLFA assays to evaluate the microbial community.



## A modern approach to microbial sampling

Bio-Trap samplers utilize a passive sampling approach allowing the results to be integrated over time rather than from a single sampling event

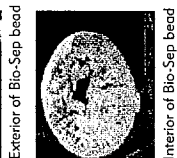


Multiple Bio-Trap samplers can be isolated from one another using a double seal cap assembly

Samplers are suspended in the screened interval for typically 30 days.  
\*study length can vary depending on objectives

## Sampling Matrix: Bio-Sep® Beads

A key to this sampling approach is the use of Bio-Sep® beads as the sampling matrix. The unique properties of these beads allow them to mimic environmental conditions very well.



Lactate amended Bio-Sep® bead

Bio-Sep® beads provide a large surface area within the bead for microbial attachment. Most microbes prefer to be attached to a surface rather than be free floating.

Fishin' for microbes! "Baited" Bio-Trap® samplers can be used to evaluate the microbial response to a wide range of amendments (electron donors and acceptors, etc.).

\*see reverse for more details

**Samplers can be analyzed using a wide variety of analyses including:**

### Molecular Biological Tools

- CENSUS® (qPCR)
- PLFA
- DGGE
- SIP

### Chemical Analysis

### Geochemical Parameters

*And more!*

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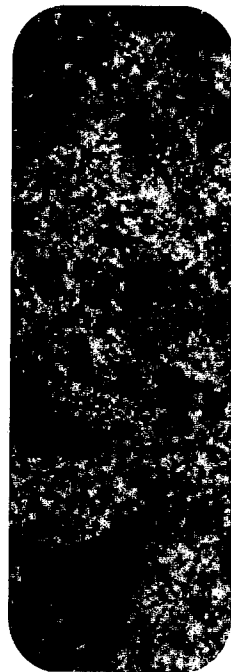
### What types of samplers are available?

Bio-Trap samplers are available in a wide variety of configurations that can be tailored to answer your site-specific questions.

**Standard:** Basic Bio-Trap® Samplers in the simplest terms are a replacement for collecting groundwater samples using a conventional approach. Most microbes prefer to be attached to a surface rather than free floating and this passive sampler provides a large surface area for the microbes to colonize. Results generated using this approach have been shown to minimize the variability associated with traditional sampling approaches. Bio-Traps biofilms have also been shown to directly reflect spatial and temporal changes in aquifer microbial community structure plume which could not be determined from groundwater analysis. Standard Bio-Trap® Samplers are primarily used during site characterization and routine monitoring activities to:

- Quantify specific microbes or contaminant degrading bacteria (e.g. *Dehalococcoides* spp.)
- Evaluate monitored natural attenuation (MNA)
- Compare microbial populations from different sampling points
- Monitor shifts within microbial communities following biostimulation

Standard Bio-Trap® Samplers are designed for microbial analyses using a variety of molecular biological tools but can also be configured for some chemical and geochemical analyses.



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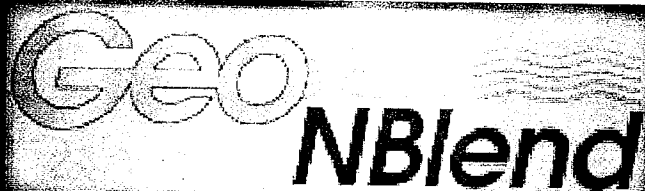
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Phone: 865.573.8188

### Baited Bio-Trap® Samplers can be amended with a number of compounds including:

- Sodium acetate
- Sodium lactate
- Potassium lactate
- HRC®
- Molasses
- Vegetable oil
- EOS®
- Sodium phosphate
- Sulfate
- Nitrate
- Ammonium chloride
- Elemental sulfur
- Calcium carbonate
- Iron (III)
- <sup>13</sup>C-labeled contaminants
  - Benzene
  - Toluene
  - Xylene
  - MTBE
  - TBA
  - Chlorobenzene
  - TCE
  - DCE
  - VC
- Fluorinated surrogates for tracing chlorinated compounds
  - TCE
  - DCE
- And more!

**Baited:** As the name suggests, Bio-Trap® Samplers can be "baited" with various amendments or compounds to answer site-specific questions. In the past, project managers have been forced to turn to laboratory microcosms or small-scale pilot studies to evaluate bioremediation as a treatment alternative. While microcosm experiments with native site materials can show biodegradation in the laboratory, duplication of *in situ* conditions is difficult and the results may not extrapolate to the field. Pilot studies are performed on site but are often prohibitively expensive as an investigative tool. Baited Bio-Trap® Samplers are designed to create discrete *in situ* microcosms that can be used to:

- Evaluate monitored natural attenuation versus enhanced bioremediation
- Compare effectiveness of different amendments (e.g. HRC®, EOS®, sodium lactate, molasses, etc.) designed to stimulate bioremediation
- Prove that biodegradation is occurring (<sup>13</sup>C-labeled compounds - Stable Isotope Probing)
- Estimate relative rates of degradation for a specific contaminant (i.e. MTBE, TBA etc.)
- Address specific questions such as:
  - Is benzene being degraded at my site?
  - Will sulfate amendments stimulate bioremediation?
  - Will sodium lactate increase the concentration of known dechlorinating bacteria?



# Denitrification-Based Bioremediation (DBB)

Anaerobic Bioremediation Technology  
for Hydrocarbon Source-Areas

DGGE Gels (right) show 16S rDNA profiles of the bacterial consortia in groundwater at three different DBB sites after N-Blend treatment. Each black band corresponds to a different organism. The band profiles of the dominant bacteria (the darkest bands) differ at each site, illustrating that N-Blend stimulates native denitrifying, hydrocarbon-degrading bacteria.

**N-Blend is a patented blend** of nitrates as both electron acceptors and N-nutrients, complex phosphates, anaerobic micronutrients, and other beneficial agents to promote the **denitrification-based bioremediation (DBB)** of source areas of hydrocarbon contamination

DBB/N-Blend is an effective means of treating high levels of sorbed-phase contamination as well as fine-grained, low-permeability media, masonry and foundation materials

DBB is an anaerobic process, so it works *with* not *against* the anaerobic and reducing conditions that typically prevail in contamination source areas

DBB stoichiometry is **more efficient** than aerobic catabolism and provides a **high energy yield** (only 5% lower than aerobic respiration)

N-Blend is a **highly concentrated solution**: it works to drive the rapid **diffusive flux** of nitrates and other active ingredients into the contaminated media to promote **DBB**

DBB is more rapid, effective and less costly for many sites

DBB/N-Blend effectiveness has been demonstrated at more than 250 sites in the U.S. and Europe where it has proven to rapidly and consistently reduce high levels of source-area hydrocarbons in relatively short time frames (e.g., months rather than years). DBB/N-Blend is in use at numerous private and DOD facilities

**Emerging DBB/N-Blend application: use as a source of anaerobic electron acceptors and nutrients to promote anaerobic oxidation as a complimentary process to reductive dechlorination for the bioremediation of chlorinated solvents**

Geovation Technologies, Inc.  
468 Route 17A, P.O. Box 293  
Florida, NY 10921  
(845) 651-4141

**GEOVATION**

[www.geovation.com](http://www.geovation.com)

Innovative Solutions to Environmental Problems

BACKGROUND PHOTO: False color digital image of a dense growth of small rod-shaped bacteria (.5  $\mu$ m x 1.5  $\mu$ m), including biofilm fragments, from free-product contaminated ground water at a N-Blend treatment site. DAPI stained cells under epifluorescent illumination (1,000 $\times$  magnification)

## **APPENDIX B**

### **STANDARD OPERATING PROCEDURES**



**TETRA TECH NUS, INC.**

# STANDARD OPERATING PROCEDURES

Number

SA-1-1

Page

1 of 25

Effective Date

09/03

Revision

5

Applicability

Tetra Tech NUS, Inc.

Prepared

Earth Sciences Department

Subject

GROUNDWATER SAMPLE ACQUISITION AND  
ONSITE WATER QUALITY TESTING

Approved

D. Senovich

## TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 PURPOSE.....	2
2.0 SCOPE.....	2
3.0 GLOSSARY .....	2
4.0 RESPONSIBILITIES.....	2
5.0 PROCEDURES.....	3
5.1 GENERAL .....	3
5.2 SAMPLING, MONITORING, AND EVACUATION EQUIPMENT.....	4
5.3 CALCULATIONS OF WELL VOLUME .....	4
5.4 EVACUATION OF STATIC WATER (PURGING) .....	5
5.4.1 General.....	5
5.4.2 Evacuation Devices.....	5
5.5 ONSITE WATER QUALITY TESTING.....	6
5.5.1 Measurement of pH.....	7
5.5.2 Measurement of Specific Conductance .....	9
5.5.3 Measurement of Temperature .....	10
5.5.4 Measurement of Dissolved Oxygen .....	11
5.5.5 Measurement of Oxidation-Reduction Potential.....	12
5.5.6 Measurement of Turbidity.....	13
5.5.7 Measurement of Salinity.....	14
5.6 SAMPLING.....	15
5.6.1 Sampling Plan .....	15
5.6.2 Sampling Methods.....	16
5.7 LOW FLOW PURGING AND SAMPLING .....	17
5.7.1 Scope & Application .....	17
5.7.2 Equipment .....	17
5.7.3 Purging and Sampling Procedure .....	18
6.0 REFERENCES.....	20

## ATTACHMENTS

A	PURGING EQUIPMENT SELECTION.....	21
B	GROUNDWATER SAMPLE LOG SHEET.....	24
C	LOW FLOW PURGE DATA SHEET .....	25

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 2 of 25
	Revision 5	Effective Date 09/03

## 1.0 PURPOSE

The purpose of this procedure is to provide general reference information regarding the sampling of groundwater wells.

## 2.0 SCOPE

This procedure provides information on proper sampling equipment, onsite water quality testing, and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require modifications to methodology.

## 3.0 GLOSSARY

Conductivity – Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions, their total concentration, mobility, valence, and relative concentrations, and on temperature of measure. Conductivity is highly dependent on temperature and should be reported at a particular temperature, i.e., 20.2 mS/cm at 14°C.

Dissolved Oxygen (DO) – DO levels in natural and wastewater depend on the physical, chemical, and biochemical activities in the water sample.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode, immersed in water, as referenced against a standard hydrogen electrode.

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration.

pH Paper - Indicator paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution's pH.

Salinity – The measurement of dissolved salts in a given mass of solution. Note: most field meters determined salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or % (e.g., 35 ppt will equal 3.5%).

Turbidity – Turbidity in water is caused by suspended matter, such as clay, silt, fine organic and inorganic matter. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample.

## 4.0 RESPONSIBILITIES

Project Hydrogeologist - Responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), and equipment to be used, and providing detailed input in this regard to the project plan documents. The project hydrogeologist is also responsible for properly briefing and overseeing the performance of the site sampling personnel.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 3 of 25
	Revision 5	Effective Date 09/03

Project Geologist/Field Sample Technician - is primarily responsible for the proper acquisition of the groundwater samples. He/she is also responsible for the actual analyses of onsite water quality samples, as well as instrument calibration, care, and maintenance. When appropriate, such responsibilities may be performed by other qualified personnel (e.g., field technicians).

## 5.0 PROCEDURES

### 5.1 General

To be useful and accurate, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of analysis in order to keep any changes in water quality parameters to a minimum.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach shall be followed prior to sample acquisition:

1. All monitoring wells shall be purged prior to obtaining a sample. Evacuation of three to five volumes is recommended prior to sampling. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, extensive evacuation prior to sample withdrawal is not as critical.
2. For wells that can be purged dry, the well shall be evacuated and allowed to recover to 75% full capacity prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is required.
3. For high-yielding monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. One of the following techniques shall be used to minimize this possibility:
  - A submersible pump or the intake line of a surface pump or bailer shall be placed just below the water surface when removing the stagnant water and lowered as the water level drops. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. Once this is accomplished, a bailer or other approved device may be used to collect the sample for analysis.
  - The intake line of the sampling pump (or the submersible pump itself) unless otherwise directed shall be placed near the center of the screened section, and approximately one casing volume of water shall be pumped from the well at a low purge rate, equal to the well's recovery rate (low flow sampling).

Stratification of contaminants may exist in the aquifer. Concentration gradients as a result of mixing and dispersion processes, layers of variable permeability, and the presence of separate-phase product (i.e.,



Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 4 of 25
	Revision 5	Effective Date 09/03

floating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column as it naturally occurs at that point, thus the result is the collection of a non-representative sample.

## 5.2 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform with the guidelines expressed in SOP SA-6.1.

The following equipment shall be on hand when sampling groundwater wells (reference SOPs SA-6.1 and SA-7.1):

- Sample packaging and shipping equipment - Coolers for sample shipping and cooling, chemical preservatives, appropriate sampling containers and filler, ice, labels and chain-of-custody documents.
- Field tools and instrumentation - Multi-parameters water quality meter capable of measuring ORP, pH, temperature, DO, specific conductance, turbidity and salinity or individual meters (as applicable), pH paper, camera and film (if appropriate), appropriate keys (for locked wells), water level indicator.
- Pumps
  - Shallow-well pumps: Centrifugal, bladder, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing) where applicable.
  - Deep-well pumps: Submersible pump and electrical power-generating unit, or bladder pumps where applicable.
- Other sampling equipment - Bailers and inert line with tripod-pulley assembly (if necessary).
- Pails - Plastic, graduated.
- Decontamination solutions - Deionized water, potable water, laboratory detergents, 10% nitric acid solution (as required), and analytical-grade solvent (e.g., pesticide-grade isopropanol), as required.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, cleaned prior to use, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging and sample collection.

## 5.3 Calculations of Well Volume

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to know the volume of standing water in the well pipe. This volume can be easily calculated by the following method. Calculations shall be entered in the site logbook or field notebook or on a sample log sheet form (see SOP SA-6.3):

- Obtain all available information on well construction (location, casing, screens, etc.).
- Determine well or inner casing diameter.
- Measure and record static water level (depth below ground level or top of casing reference point).
- Determine depth of well by sounding using a clean, decontaminated, weighted tape measure.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 5 of 25
	Revision 5	Effective Date 09/03

- Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).

- Calculate one static well volume in gallons  $V = (0.163)(T)(r^2)\pi$

where:  $V$  = Static volume of well in gallons.  
 $T$  = Thickness of water table in the well measured in feet (i.e., linear feet of static water).  
 $r$  = Inside radius of well casing in inches.  
 $0.163$  = A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.

- Per evacuation volumes discussed above, determine the minimum amount to be evacuated before sampling.

#### 5.4 Evacuation of Static Water (Purging)

##### 5.4.1 General

The amount of purging a well shall receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately the well can be pumped until the parameters such as temperature, specific conductance, pH, and turbidity (as applicable), have stabilized. Onsite measurements of these parameters shall be recorded in the site logbook, field notebook, or on standardized data sheets.

##### 5.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment A provides guidance on the proper evacuation device to use for given sampling situations. Note that all of these techniques involve equipment which is portable and readily available.

##### Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Bailers are inexpensive, and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 6 of 25
	Revision 5	Effective Date 09/03

- It is time consuming to remove stagnant water using a bailer.
- Transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.

#### Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, and peristaltic pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause significant loss of dissolved gases and volatile organics.

#### Air-Lift Samplers

This group of pump samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Air (or gas)-lift samplers are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation, or loss of volatile organics.

#### Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch-diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- They may have low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components can be difficult and time-consuming.

### **5.5      Onsite Water Quality Testing**

This section describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific Conductance
- Temperature
- Dissolved Oxygen (DO)
- Oxidation-Reduction Potential (ORP)

Subject <b>GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING</b>	Number <b>SA-1-1</b>	Page <b>7 of 25</b>
	Revision <b>5</b>	Effective Date <b>09/03</b>

- Turbidity
- Salinity

This section is applicable for use in an onsite groundwater quality monitoring program to be conducted at a hazardous or nonhazardous site. The procedures and equipment described are applicable to groundwater samples and are not, in general, subject to solution interferences from color, turbidity, and colloidal material or suspended matter.

This section provides general information for measuring the parameters listed above with instruments and techniques in common use. Since instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use. Most meters used to measure field parameters require calibration on a daily basis. Refer to SOP 6.3 for example equipment calibration log.

### **5.5.1 Measurement of pH**

#### **5.5.1.1 General**

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken.

Two methods are given for pH measurement: the pH meter and pH indicator paper. The indicator paper is used when only a rough estimate of the pH is required, and the pH meter when a more accurate measurement is needed. The response of a pH meter can be affected to a slight degree by high levels of colloidal or suspended solids, but the effect is usually small and generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

#### **5.5.1.2 Principles of Equipment Operation**

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or alkalinity of the solution created by the addition of the water sample reacting with the indicator compound on the paper. Various types of pH papers are available, including litmus (for general acidity or alkalinity determination) and specific pH range hydron paper.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to (in this instance, hydrogen) ion concentration across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to the ion concentration is generated and measured.

#### **5.5.1.3 Equipment**

The following equipment is needed for taking pH measurements:

- Stand-alone portable pH meter, or combination meter (e.g., Horiba U-10), or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 8 of 25
	Revision 5	Effective Date 09/03

- Combination electrode with polymer body to fit the above meter (alternately a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs).
- Buffer solutions, as specified by the manufacturer.
- pH indicator paper, to cover the pH range 2 through 12.
- Manufacturer's operation manual.

#### 5.5.1.4 Measurement Techniques for Field Determination of pH

##### pH Meter

The following procedure is used for measuring pH with a pH meter (meter standardization is according to manufacturer's instructions):

- Inspect the instrument and batteries prior to initiation of the field effort.
- Check the integrity of the buffer solutions used for field calibration. Buffer solutions need to be changed often as a result of degradation upon exposure to the atmosphere.
- If applicable, make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).
- Calibrate on a daily use basis (or as recommended by manufacturer) following manufacturer's instructions. Record calibration data on an equipment calibration log sheet.
- Immerse the electrode(s) in the sample. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a physical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.
- Read and record the pH of the sample. pH shall be recorded to the nearest 0.01 pH unit. Also record the sample temperature.
- Rinse the electrode(s) with deionized water.
- Store the electrode(s) in an appropriate manner when not in use.

Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted.

##### pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper and proceed with successively narrower range paper until the sample pH is adequately determined.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 9 of 25
	Revision 5	Effective Date 09/03

## 5.5.2 Measurement of Specific Conductance

### 5.5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of the ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance measurement soon after taking a sample, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance. Most conductivity meters in use today display specific conductance (SC); units of milliSiemens per centimeter, which is the conductivity normalized to temperature @ 25°C. This format (SC) is the required units recorded on the groundwater sample log field form (Attachment B).

### 5.5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, while the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases and salts (such as hydrochloric acid, sodium carbonate, or sodium chloride, respectively) are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not dissociate in aqueous solution, conduct a current very poorly, if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

### 5.5.2.3 Equipment

The following equipment is needed for taking specific conductance (SC) measurements:

- Stand alone portable conductivity meter, or combination meter (e.g., Horiba U-10), or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

A variety of conductivity meters are available which may also be used to monitor salinity and temperature. Probe types and cable lengths vary, so equipment must be obtained to meet the specific requirement of the sampling program.

### 5.5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are listed below (standardization is according to manufacturer's instructions):

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 10 of 25
	Revision 5	Effective Date 09/03

- Check batteries and calibrate instrument before going into the field.
- Calibrate on a daily use basis (or as recommended by manufacturer), according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet. Potassium chloride solutions with a SC closest to the values expected in the field shall be used for calibration.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the electrode in the sample and measure the conductivity.
- Read and record the results in a field logbook or sample log sheet.
- Rinse the electrode with deionized water.

If the specific conductance measurements become erratic, recalibrate the instrument and see the manufacturer's instructions for details.

### 5.5.3 Measurement of Temperature

#### 5.5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in-situ, or as quickly as possible in the field. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

#### 5.5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury filled, dial-type thermometers or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).. In addition, various meters such as specific conductance or dissolved oxygen meters, which have temperature measurement capabilities, may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

#### 5.5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used to determine the temperature for a water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of cross-contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.
- Record values in a field logbook or sample log sheet.

If a temperature meter or probe is used, the instrument shall be calibrated according to manufacturer's recommendations.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 11 of 25
	Revision 5	Effective Date 09/03

#### **5.5.4 Measurement of Dissolved Oxygen**

##### **5.5.4.1 General**

Dissolved oxygen (DO) levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. Conversely, the growth of many aquatic organisms as well as the rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for dissolved oxygen is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in-situ, since concentration may show a large change in a short time if the sample is not adequately preserved.

The monitoring method discussed herein is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible, and is not susceptible to interference caused by color, turbidity, colloidal material or suspended matter.

##### **5.5.4.2 Principles of Equipment Operation**

Dissolved oxygen probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion ( $\text{OH}^-$ ) occurs at the cathode surface. An electrical current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode.

Since the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, while leaving the surface of the solution undisturbed.

Dissolved oxygen probes are relatively unaffected by interferences. Interferences that can occur are reactions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide, which are not easily depolarized from the indicating electrode. If a gaseous interference is suspected, it shall be noted in the field log book and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer.

##### **5.5.4.3 Equipment**

The following equipment is needed to measure dissolved oxygen concentration:

- Stand alone portable dissolved oxygen meter, or combination meter (e.g., Horiba U-10), or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Sufficient cable to allow the probe to contact the sample.
- Manufacturer's operation manual.



Subject <b>GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING</b>	Number <b>SA-1-1</b>	Page <b>12 of 25</b>
	Revision <b>5</b>	Effective Date <b>09/03</b>

#### 5.5.4.4 Measurement Techniques for Dissolved Oxygen Determination

Probes differ as to specifics of use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure the dissolved oxygen concentration:

- The equipment shall be calibrated and have its batteries checked before going to the field.
- The probe shall be conditioned in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.
- The instrument shall be calibrated in the field according to manufacturer's recommendations or in a freshly air-saturated water sample of known temperature.
- Record all pertinent information on an equipment calibration sheet.
- Rinse the probe with deionized water.
- Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane by stirring the sample. Probes without stirrers placed in wells can be moved up and down.
- Record the dissolved oxygen content and temperature of the sample in a field logbook or sample log sheet.
- Rinse the probe with deionized water.
- Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable, since sample handling is not involved. This however, may not always be practical.

Special care shall be taken during sample collection to avoid turbulence which can lead to increased oxygen solubilization and positive test interferences.

#### 5.5.5 **Measurement of Oxidation-Reduction Potential**

##### 5.5.5.1 General

The oxidation-reduction potential (ORP) provides a measure of the tendency of organic or inorganic compounds to exist in an oxidized state. The ORP parameter therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of oxidized to reduced species in the sample.

##### 5.5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and is dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental

Subject <b>GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING</b>	Number <b>SA-1-1</b>	Page <b>13 of 25</b>
	Revision <b>5</b>	Effective Date <b>09/03</b>

measurements, such as dissolved oxygen, may be correlated with ORP to provide a knowledge of the quality of the solution, water, or wastewater.

#### 5.5.5.3 Equipment

The following equipment is needed for measuring the oxidation-reduction potential of a solution:

- Combination meters with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Reference solution as specified by the manufacturer.
- Manufacturer's operation manual.

#### 5.5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring oxidation-reduction potential:

- The equipment shall be checked using the manufacturer's recommended reference solution and have its batteries checked before going to the field.
- Thoroughly rinse the electrode with deionized water.
- If the probe does not respond properly to the recommended reference solution, then verify the sensitivity of the electrodes by noting the change in millivolt reading when the pH of a test solution is altered. The ORP will increase when the pH of a test solution decreases, and the ORP will decrease if the test solution pH is increased. Place the sample in a clean container and agitate the sample. Insert the electrodes and note the ORP drops sharply when the caustic is added (i.e., pH is raised) thus indicating the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions or the probe should be replaced.
- Record all pertinent information on an equipment calibration log sheet.

### 5.5.6 **Measurement of Turbidity**

#### 5.5.6.1 General

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample. Turbidity in water is caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, and microscopic organisms, including plankton.

It is important to obtain a turbidity reading immediately after taking a sample, since irreversible changes in turbidity may occur if the sample is stored too long.

#### 5.5.6.2 Principles of Equipment Operation

Turbidity is measured by the Nephelometric Method. This method is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the scattered light intensity, the higher the turbidity.

Formazin polymer is used as the reference turbidity standard suspension because of its ease of preparation combined with a higher reproducibility of its light-scattering properties than clay or turbid

Subject <b>GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING</b>	Number <b>SA-1-1</b>	Page <b>14 of 25</b>
	Revision <b>5</b>	Effective Date <b>09/03</b>

natural water. The turbidity of a specified concentration of formazin suspension is defined as 40 nephelometric units. This same suspension has an approximate turbidity of 40 Jackson units when measured on the candle turbidimeter. Therefore, nephelometric turbidity units (NTU) based on the formazin preparation will approximate units derived from the candle turbidimeter but will not be identical to them.

#### 5.5.6.3 Equipment

The following equipment is needed for turbidity measurement:

- Light meter (e.g., LaMotte 2020) which calibrates easily using test cells with standards of 0.0 NTUs, and 10 NTUs, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

#### 5.5.6.4 Measurement Techniques for Turbidity

The steps involved in taking turbidity measurements utilizing an electrode (e) or light meter (l) are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate instrument before going into the field.
- Check the expiration date (etc.) of the solutions used for field calibration.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet.
- Rinse the electrode with one or more portions of the sample to be tested or with deionized water (applies to "e").
- Fill the light meters glass test cell with ~5 ml of sample, screw on cap, wipe off glass, place test cell in light meter and close the lid (applies to "l").
- Immerse the electrode in the sample and measure the turbidity (applies to "e").
- The reading must be taken immediately as suspended solids will settle over time resulting in a lower, inaccurate turbidity reading.
- Read and record the results in a field logbook or sample log sheet. Include a physical description of the sample, including color, qualitative estimate of turbidity, etc.
- Rinse the electrode or test cell with deionized water.

### 5.5.7 **Measurement of Salinity**

#### 5.5.7.1 General

Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved salts in a given mass of solution. Note: Most field meters determined salinity automatically from conductivity and

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 15 of 25
	Revision 5	Effective Date 09/03

temperature. The displayed value will be displayed in either parts per thousand (ppt) or % (e.g., 35 ppt will equal 3.5%).

#### 5.5.7.2 Principles of Equipment Operation

Salinity is determined automatically from the meter's conductivity and temperature readings according to algorithms (found in *Standard methods for the Examination of Water and Wastewater*). Depending on the meter, the results are displayed in either ppt or %. The salinity measurements are carried out in reference to the conductivity of standard seawater (*corrected to S = 35*).

#### 5.5.7.3 Equipment

The following equipment is needed for Salinity measurements:

- Multi-parameter water quality meter capable of measuring conductive, temperature and converting them to salinity (e.g., Horiba U-10 or YSI 600 series).
- Calibration Solution, as specified by the manufacturer.
- Manufacturer's operation manual.

#### 5.5.7.4 Measurement Techniques for Salinity

The steps involved in taking Salinity measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate before going into the field.
- Check the expiration date (etc.) of the solutions used for field calibration.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet.
- Rinse the cell with the sample to be tested.
- Immerse the multi-probe in the sample and measure the salinity. Read and record the results in a field logbook or sample log sheet.
- Rinse the probes with deionized water.

### 5.6 Sampling

#### 5.6.1 Sampling Plan

The sampling approach consisting of the following, shall be developed as part of the project plan documents which are approved prior to beginning work in the field:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 16 of 25
	Revision 5	Effective Date 09/03

- Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.
- Sample preservation requirements.
- Work schedule.
- List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

#### 5.6.2 Sampling Methods

The collection of a groundwater sample consists of the following steps:

1. The site Health & Safety Officer (or designee) will first open the well cap and use volatile organic detection equipment (PID or FID) on the escaping gases at the well head to determine the need for respiratory protection.
2. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data on a groundwater sampling log sheet (see Attachment B); then calculate the fluid volume in the well pipe (as previously described in this SOP).
3. Calculate well volume to be removed as stated in Section 5.3.
4. Select the appropriate purging equipment (see Attachment A). If an electric submersible pump with packer is chosen, go to Step 10.
5. Lower the purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner (as applicable). Lower the purging device, as required, to maintain submergence.
6. Measure the rate of discharge frequently. A graduated bucket or cylinder and stopwatch are most commonly used.
7. Observe the peristaltic pump intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics.
8. Purge a minimum of three to five casing volumes before sampling. In low-permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Purged water shall be collected in a designated container and disposed in an acceptable manner.
9. If sampling using a pump, lower the pump intake to midscreen (or the middle of the open section in uncased wells) and collect the sample. If sampling with a bailer, lower the bailer to just below the water surface.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 17 of 25
	Revision 5	Effective Date 09/03

10. (For pump and packer assembly only). Lower the assembly into the well so that the packer is positioned just above the screen or open section. Inflate the packer. Purge a volume equal to at least twice the screened interval (or unscreened open section volume below the packer) before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.
11. In the event that recovery time of the well is very slow (e.g., 24 hours or greater), sample collection can be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record this occurrence in the site logbook.
12. Fill sample containers (preserve and label as described in SOP SA-6.1).
13. Replace the well cap and lock as appropriate. Make sure the well is readily identifiable as the source of the samples.
14. Process sample containers as described in SOP SA-6.1.
15. Decontaminate equipment as described in SOP SA-7.1.

## 5.7 Low Flow Purging and Sampling

### 5.7.1 **Scope & Application**

Low flow purging and sampling techniques are sometimes required for groundwater sampling activities. The purpose of low flow purging and sampling is to collect groundwater samples that contain "representative" amounts of mobile organic and inorganic constituents in the vicinity of the selected open well interval, at or near natural flow conditions. The minimum stress procedure emphasizes negligible water level drawdown and low pumping rates in order to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 1 inch or more and a saturated screen, or open interval, length of ten feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (volatile and semi-volatile organic compounds, pesticides, PCBs, metals and other inorganic ions [cyanide, chloride, sulfate, etc.]). This procedure is not designed to collect non-aqueous phase liquids samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs), using the low flow pumps.

The procedure is flexible for various well construction types and groundwater yields. The goal of the procedure is to obtain a turbidity level of less than 10 NTU and to achieve a water level drawdown of less than 0.3 feet during purging and sampling. If these goals cannot be achieved, sample collection can take place provided the remaining criteria in this procedure are met.

### 5.7.2 **Equipment**

The following equipment is required (as applicable) for low flow purging and sampling:

- Adjustable rate, submersible pump (e.g., centrifugal or bladder pump constructed of stainless steel or Teflon).
- Disposable clear plastic bottom filling bailers may be used to check for and obtain samples of LNAPLs or DNAPLs.

Subject <b>GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING</b>	Number	Page
	SA-1-1	18 of 25
	Revision 5	Effective Date 09/03

- Tubing - Teflon, Teflon-lined polyethylene, polyethylene, PVC, Tygon, or stainless steel tubing can be used to collect samples for analysis, depending on the analyses to be performed and regulatory requirements.
- Water level measuring device, 0.01 foot accuracy, (electronic devices are preferred for tracking water level drawdown during all pumping operations).
- Interface probe, if needed.
- Flow measurement supplies.
- Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples.
- Indicator parameter monitoring instruments - pH, turbidity, specific conductance, and temperature. Use of a flow-through cell is recommended. Optional Indicators - ORP, salinity, and dissolved oxygen, flow-through cell is required. Standards to perform field calibration of instruments.
- Decontamination supplies.
- Logbook(s), and other forms (see Attachments B and C).
- Sample Bottles.
- Sample preservation supplies (as required by the analytical methods).
- Sample tags and/or labels.
- Well construction data, location map, field data from last sampling event (if available).
- Field Sampling Plan.
- PID or FID instrument for measuring VOCs (volatile organic compounds).

### **5.7.3 Purging and Sampling Procedure**

Open monitoring well, measure head space gases using PID/FID. If there is an indication of off gassing when opening the well, wait 3-5 minutes to permit water level an opportunity to reach equilibrium.

Measure and record the water level immediately prior to placing the pump in the well.

Lower pump or tubing slowly into the well so that the pump intake is located at the center of the saturated screen length of the well. If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of sediment that may be present in the bottom of the well. Collection of turbidity-free water samples may be difficult if there is three feet or less of standing water in the well.

Start with the initial pump rate set at approximately 0.1 liters/minute. Use a graduated cylinder and stopwatch to measure the pumping rate. Adjust pumping rates as necessary to prevent drawdown from exceeding 0.3 feet during purging. If no drawdown is noted, the pump rate may be increased (to a max of 0.4 liters/minute) to expedite the purging and sampling event. The pump rate will be reduced if turbidity is greater than 10 NTUs after all other field parameters have stabilized. If groundwater is drawn down below

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 19 of 25
	Revision 5	Effective Date 09/03

the top of the well screen, purging will cease or the well will be pumped to dryness and the well will be allowed to recover before purging continues. Slow recovering wells will be identified and purged at the beginning of the workday. If possible, samples will be collected from these wells within the same workday and no later than 24 hours after the start of purging.

Measure the well water level using the water level meter every 5 to 10 minutes. Record the well water level on the Low-Flow Purge Data Form (Attachment C).

Record on the Low-Flow Purge Data Form every 5 to 10 minutes the water quality parameters (pH, specific conductance, temperature, turbidity, oxidation-reduction potential, dissolved oxygen and salinity or as specified by the approved site specific work plan) measured by the water quality meter and turbidity meter. If the cell needs to be cleaned during purging operations, continue pumping (allow the pump to discharge into a container) and disconnect the cell. Rinse the cell with distilled/deionized water. After cleaning is completed, reconnect the flow-through cell and continue purging. Document the cell cleaning on the Low-Flow Purge Data Form.

Measure the flow rate using a graduated cylinder. Remeasure the flow rate any time the pump rate is adjusted.

During purging, check for the presence of bubbles in the flow-through cell. The presence of bubbles is an indication that connections are not tight. If bubbles are observed, check for loose connections.

After stabilization is achieved, sampling can begin when a minimum of two saturated screen volumes have been removed and three consecutive readings, taken at 5 to 10 minute intervals, are within the following limits:

- pH  $\pm 0.2$  standard units
- Specific conductance  $\pm 10\%$
- Temperature  $\pm 10\%$
- Turbidity less than 10 NTUs
- Dissolved oxygen  $\pm 10\%$

If the above conditions have still not been met after the well has been purged for 4 hours, purging will be considered complete and sampling can begin. Record the final well stabilization parameters from the Low-Flow Purge Data Form onto the Groundwater Sample Log Form.

VOC samples are preferably collected first, directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

If the water column in the pump tubing collapses (water does not completely fill the tubing) before exiting the tubing, use one of the following procedures to collect VOC samples: (1) Collect the non-VOCs samples first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample and record the new flow rate; (2) reduce the diameter of the existing tubing until the water column fills the tubing either by adding a connector (Teflon or stainless steel), or clamp which should reduce the flow rate by constricting the end of the tubing; (3) insert a narrow diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, collect sample from the narrow diameter tubing.

Prepare samples for shipping as per SOP SA-6.1.



Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 20 of 25
	Revision 5	Effective Date 09/03

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Subject <b>GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING</b>	Number <b>SA-1-1</b>	Page <b>21 of 25</b>
	Revision <b>5</b>	Effective Date <b>09/03</b>

## ATTACHMENT A

### PURGING EQUIPMENT SELECTION

Diameter Casing		Bailer	Peristaltic Pump	Vacuum Pump	Air-lift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-Inch	Water level <25 feet	X	X	X	X	X			
	Water Level >25 feet	X			X				
2-Inch	Water level <25 feet	X	X	X	X	X	X		
	Water Level >25 feet	X			X		X		
4-Inch	Water level <25 feet	X	X	X	X	X	X	X	X
	Water Level >25 feet	X			X		X	X	X
6-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X
8-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X

**ATTACHMENT A**  
**PURGING EQUIPMENT SELECTION**  
**PAGE 2**

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/L length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	Dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 feet of submergence	\$220-350	Requires compressed gas; custom sizes and materials available; acts as piezometer.
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	Portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	\$500-600	AC/DC; variable speed control available; other models may have different flow rates.
ECO Pump Corp.	SAMPLifier	Portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	\$400-700	AC, DC, or gasoline-driven motors available; must be primed.
Geltek Corp.	Bailer 219-4	Portable; grab (positive displacement)	1.66/38	Teflon®	No limit	1,075 mL	\$120-135	Other sizes available.
GeoEngineering, Inc.	GEO-MONITOR	Dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	Probably 0-150	Approximately 1 liter for each 10 feet of submergence	\$185	Acts as piezometer; requires compressed gas.
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	Portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2,800 mL/min	\$1,500-3,000	Requires compressed gas; other models available; AC, DC, manual operation possible.
IEA	Syringe Sampler	Portable; grab (positive displacement)	1.75/43	SS, Teflon®	No limit	850 mL sample volume	\$1,100	Requires vacuum and/or pressure from hand pump.
Instrument Specialties Co. (ISCO)	Model 2800 Well Sampler	Portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon®, PP, PE, Detrin®, acetal	0-150	0-7,500 mL/min	\$990	Requires compressed gas (40 psi minimum).
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	Portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4,500 mL/min	\$3,500	DC operated.
Leonard Mold and Die Works, Inc.	GeoFilter. Small Diameter Well Pump (#0500)	Portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3,500 mL/min	\$1,400-1,500	Requires compressed gas (55 psi minimum); pneumatic or AC/DC control module.
Oil Recovery Systems, Inc.	Surface Sampler	Portable; grab (positive displacement)	1.75/12	acrylic, Detrin®	No limit	Approximately 250 mL	\$125-160	Other materials and models available; for measuring thickness of "floating" contaminants.
Q.E.D. Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	Dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2,000 mL/min	\$300-400	Requires compressed gas; piezometric level indicator; other materials available.

**ATTACHMENT A**  
**PURGING EQUIPMENT SELECTION**  
**PAGE 3**

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/L ength (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
Randolph Ausfin Co.	Model 500 Vari-Flow Pump	Portable; peristaltic (suction)	<0.5/NA	(Not submersible) Rubber, Tygon®, or Neoprene®	0-30	See comments	\$1,200-1,300	Flow rate dependent on motor and tubing selected; AC operated; other models available.
Robert Bennett Co.	Model 180	Portable; piston (positive displacement)	1.8/22	SS, Teflon® Delrin® PP, Viton®, acrylic, PE	0-500	0-1,800 mL/min	\$2,600-2,700	Requires compressed gas; water level indicator and flow meter; custom models available.
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	Portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1,100	250 mL/flushing cycle	\$250-350	Requires compressed gas; SS available; piezometer model available; dedicated model available.
Solinst Canada Ltd.	5W Water Sampler	Portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	\$1,300-1,800	Requires compressed gas; custom models available.
TIMCO Mfg. Co., Inc.	Std. Bailor	Portable; grab (positive displacement)	1.66/Custom	PVC, PP	No limit	250 mL/ft of bailer	\$20-60	Other sizes, materials, models available; optional bottom-emptying device available; no solvents used.
TIMCO	Air or Gas Lift Sampler	Portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	\$100-200	Requires compressed gas; other sizes, materials, models available; no solvents used.
Tote Devices Co.	Sampling Pump	Portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4,000 mL/min	\$800-1,000	Compressed gas required; DC control module; custom built.

## Construction Material Abbreviations:

PE Polyethylene  
PP Polypropylene  
PVC Polyvinyl chloride  
SS Stainless steel  
PC Polycarbonate  
EPDM Ethylene-propylene diene (synthetic rubber)

## Other Abbreviations:

NA Not applicable  
AC Alternating current  
DC Direct current

NOTE: Other manufacturers market pumping devices which could be used for groundwater sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983.

Page 24 of 25

Effective Date 09/03

**Tetra Tech NUS, Inc.**

## Page\_\_ of \_\_

☒ Low Concentration  
☐ High Concentration

[illegible]





TETRA TECH NUS, INC.

# STANDARD OPERATING PROCEDURES

Number

SA-6.1

Page

1 of 11

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3

Applicability

Tetra Tech NUS, Inc.

Prepared

Earth Sciences Department

Approved

D. Senovich

Subject

NON-RADIOLOGICAL SAMPLE HANDLING

## TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 PURPOSE.....	2
2.0 SCOPE.....	2
3.0 GLOSSARY .....	2
4.0 RESPONSIBILITIES.....	3
5.0 PROCEDURES.....	3
5.1 SAMPLE CONTAINERS .....	3
5.2 SAMPLE PRESERVATION.....	3
5.2.1 Overview .....	4
5.2.2 Preparation and Addition of Reagents .....	4
5.3 FIELD FILTRATION .....	5
5.4 SAMPLE PACKAGING AND SHIPPING.....	6
5.4.1 Environmental Samples .....	6
6.0 REFERENCES.....	7
 <u>ATTACHMENTS</u>	
A GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS .....	8
B ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES .....	9



Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 2 of 11
	Revision 3	Effective Date 02/04

## 1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide information on sample preservation, packaging, and shipping procedures to be used in handling environmental samples submitted for chemical constituent, biological, or geotechnical analysis. Sample chain-of-custody procedures and other aspects of field documentation are addressed in SOP SA-6.3. Sample identification is addressed in SOP CT-04.

## 2.0 SCOPE

This procedure describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped off site for chemical analysis.

## 3.0 GLOSSARY

Hazardous Material - A substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated. Under 49 CFR, the term includes hazardous substances, hazardous wastes, marine pollutants, and elevated temperature materials, as well as materials designated as hazardous under the provisions of §172.101 and §172.102 and materials that meet the defining criteria for hazard classes and divisions in Part 173. With slight modifications, IATA has adopted DOT "hazardous materials" as IATA "Dangerous Goods."

Hazardous Waste - Any substance listed in 40 CFR, Subpart D (y261.30 et seq.), or otherwise characterized as ignitable, corrosive, reactive, or toxic (as defined by Toxicity Characteristic Leaching Procedure, TCLP, analysis) as specified under 40 CFR, Subpart C (y261.20 et seq.), that would be subject to manifest requirements specified in 40 CFR 262. Such substances are defined and regulated by EPA.

Marking - A descriptive name, identification number, instructions, cautions, weight, specification or UN marks, or combination thereof required on outer packaging of hazardous materials.

n.o.i - Not otherwise indicated (may be used interchangeably with n.o.s.).

n.o.s. - Not otherwise specified.

Packaging - A receptacle and any other components or materials necessary for compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, and multi-unit tank-car tanks to perform a containment function in conformance with the minimum packaging requirements of 49 CFR 173.24(a) & (b).

Placard - Color-coded, pictorial sign which depicts the hazard class symbol and name and which is placed on the side of a vehicle transporting certain hazardous materials.

### Common Preservatives:

- Hydrochloric Acid - HCl
- Sulfuric Acid - H<sub>2</sub>SO<sub>4</sub>
- Nitric Acid - HNO<sub>3</sub>
- Sodium Hydroxide - NaOH

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 3 of 11
	Revision 3	Effective Date 02/04

#### Other Preservatives

- Zinc Acetate
- Sodium Thiosulfate -  $\text{Na}_2\text{S}_2\text{O}_3$

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing 1 gram-atom of replaceable hydrogen or its equivalent.

Reportable Quantity (RQ) - For the purposes of this SOP, means the quantity specified in column 3 of the Appendix to DOT 49 CFR §172.101 for any material identified in column 1 of the appendix. A spill greater than the amount specified must be reported to the National Response Center.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the location and time of collection.

#### **4.0 RESPONSIBILITIES**

Field Operations Leader - Directly responsible for the bottling, preservation, labeling, packaging, shipping, and custody of samples up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record (per SOP SA-6.3), implementing the packaging and shipping requirements, and maintaining custody of samples until they are relinquished to another custodian or to the shipper.

#### **5.0 PROCEDURES**

Sample identification, labeling, documentation, and chain-of-custody are addressed by SOP SA-6.3.

##### **5.1 Sample Containers**

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, whereas many organic chemicals may dissolve various types of plastic containers. Attachments A and B show proper containers (as well as other information) per 40 CFR 136. In general, the sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample warms during transport. However, for collection of volatile organic compounds, head space shall be omitted. The analytical laboratory will generally provide certified-clean containers for samples to be analyzed for chemical constituents. Shelby tubes or other sample containers are generally provided by the driller for samples requiring geotechnical analysis. Sufficient lead time shall be allowed for a delivery of sample container orders. Therefore, it is critical to use the correct container to maintain the integrity of the sample prior to analysis.

Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded. Because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or a missing Teflon liner (if required for the container), shall be discarded.

##### **5.2 Sample Preservation**

Many water and soil samples are unstable and therefore require preservation to prevent changes in either the concentration or the physical condition of the constituent(s) requiring analysis. Although complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological

Subject <b>NON-RADIOLOGICAL SAMPLE HANDLING</b>	Number <b>SA-6.1</b>	Page <b>4 of 11</b>
	Revision <b>3</b>	Effective Date <b>02/04</b>

changes that inevitably take place after the sample is collected. Preservation techniques are usually limited to pH control, chemical addition(s), and refrigeration/ freezing (certain biological samples only).

### 5.2.1 Overview

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the field or be added in the field (in a clean environment). Only high purity reagents shall be used for preservation. In general, aqueous samples of low-concentration organics (or soil samples of low- or medium-concentration organics) are cooled to 4°C. Medium-concentration aqueous samples, high-hazard organic samples, and some gas samples are typically not preserved. Low-concentration aqueous samples for metals are acidified with HNO<sub>3</sub>, whereas medium-concentration and high-hazard aqueous metal samples are not preserved. Low- or medium-concentration soil samples for metals are cooled to 4°C, whereas high-hazard samples are not cooled.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

The FOL is responsible for ensuring that an accurate Chemical Inventory is created and maintained for all hazardous chemicals brought to the work site (see Section 5 of the TtNUS Health and Safety Guidance Manual). Furthermore, the FOL must ensure that a corresponding Material Safety Data Sheet (MSDS) is collected for every substance entered on the site Chemical Inventory, and that all persons using/handling/ disposing of these substances review the appropriate MSDS for substances they will work with. The Chemical Inventory and the MSDSs must be maintained at each work site in a location and manner where they are readily-accessible to all personnel.

### 5.2.2 Preparation and Addition of Reagents

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade or purer and shall be diluted to the required concentration with deionized water before field sampling commences. To avoid uncontrolled reactions, be sure to Add Acid to water (not vice versa). A dilutions guide is provided below.

<b>Acid/Base</b>	<b>Dilution</b>	<b>Concentration</b>	<b>Estimated Amount Required for Preservation</b>
Hydrochloric Acid (HCl)	1 part concentrated HCl: 1 part double-distilled, deionized water	6N	5-10 mL
Sulfuric Acid (H <sub>2</sub> SO <sub>4</sub> )	1 part concentrated H <sub>2</sub> SO <sub>4</sub> : 1 part double-distilled, deionized water	18N	2 - 5 mL
Nitric Acid (HNO <sub>3</sub> )	Undiluted concentrated HNO <sub>3</sub>	16N	2 - 5 mL
Sodium Hydroxide (NaOH)	400 grams solid NaOH dissolved in 870 mL double-distilled, deionized water; yields 1 liter of solution	10N	2 mL

The amounts required for preservation shown in the above table assumes proper preparation of the preservative and addition of the preservative to one liter of aqueous sample. This assumes that the sample is initially at pH 7, is poorly buffered, and does not contain particulate matter; as these conditions vary, more preservative may be required. Consequently, the final sample pH must be checked using narrow-range pH paper, as described in the generalized procedure detailed below:

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 5 of 11
	Revision 3	Effective Date 02/04

- Pour off 5-10 mL of sample into a dedicated, clean container. Use some of this sample to check the initial sample pH using wide range (0-14) pH paper. Never dip the pH paper into the sample; always apply a drop of sample to the pH paper using a clean stirring rod or pipette.
- Add about one-half of the estimated preservative required to the original sample bottle. Cap and invert gently several times to mix. Check pH (as described above) using medium range pH paper (pH 0-6 or pH 7.5-14, as applicable).
- Cap sample bottle and seal securely.

Additional considerations are discussed below:

- To test if ascorbic acid must be used to remove oxidizing agents present in the sample before it can be properly preserved, place a drop of sample on KI-starch paper. A blue color indicates the need for ascorbic acid addition.

If required, add a few crystals of ascorbic acid to the sample and retest with the KI-starch paper. Repeat until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 grams of ascorbic acid per each liter of sample volume.

Continue with proper base preservation of the sample as described above.

- Samples for sulfide analysis must be treated by the addition of 4 drops (0.2 mL) of 2N zinc acetate solution per 100 ml of sample.

The 2N zinc acetate solution is made by dissolving 220 grams of zinc acetate in 870 mL of double-distilled, deionized water to make 1 liter of solution.

The sample pH is then raised to 9 using the NaOH preservative.

- Sodium thiosulfate must be added to remove residual chlorine from a sample. To test the sample for residual chlorine use a field test kit specially made for this purpose.

If residual chlorine is present, add 0.08 grams of sodium thiosulfate per liter of sample to remove the residual chlorine.

Continue with proper acidification of the sample as described above.

For biological samples, 10% buffered formalin or isopropanol may also be required for preservation. Questions regarding preservation requirements should be resolved through communication with the laboratory before sampling begins.

### 5.3 Field Filtration

At times, field-filtration may be required to provide for the analysis of dissolved chemical constituents. Field-filtration must be performed prior to the preservation of samples as described above. General procedures for field filtration are described below:

- The sample shall be filtered through a non-metallic, 0.45-micron membrane filter, immediately after collection. The filtration system shall consist of dedicated filter canister, dedicated tubing, and a peristaltic pump with pressure or vacuum pumping squeeze action (since the sample is filtered by mechanical peristalsis, the sample travels only through the tubing).

Subject <b>NON-RADIOLOGICAL SAMPLE HANDLING</b>	Number <b>SA-6.1</b>	Page <b>6 of 11</b>
	Revision <b>3</b>	Effective Date <b>02/04</b>

- To perform filtration, thread the tubing through the peristaltic pump head. Attach the filter canister to the discharge end of the silicon tubing (note flow direction arrow); attach the aqueous sample container to the intake end of the silicon tubing. Turn the peristaltic pump on and perform filtration. Run approximately 100 ml of sample through the filter and discard prior to sample collection.
- Continue by preserving the filtrate (contained in the filter canister), as applicable and generally described above.

#### **5.4      Sample Packaging and Shipping**

Only employees who have successfully completed the TiNUS "Shipping Hazardous Materials" training course are authorized to package and ship hazardous substances. These trained individuals are responsible for performing shipping duties in accordance with this training.

Samples collected for shipment from a site shall be classified as either environmental or hazardous material samples. Samples from drums containing materials other than Investigative Derived Waste (IDW) and samples obtained from waste piles or bulk storage tanks are generally shipped as hazardous materials. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples (if there is any doubt, a sample shall be considered hazardous and shipped accordingly.)
- Protect the health and safety of transport and laboratory personnel receiving the samples (special precautions are used by the shipper and at laboratories when hazardous materials are received.)

Detailed procedures for packaging environmental samples are outlined in the remainder of this section.

##### **5.4.1      Environmental Samples**

Environmental samples are packaged as follows:

- Place properly identified sample container, with lid securely fastened, in a plastic bag (e.g. Ziploc baggie), and seal the bag.
- Place sample in a cooler constructed of sturdy material which has been lined with a large, plastic bag (e.g. "garbage" bag). Drain plugs on coolers must be taped shut.
- Pack with enough cushioning materials such as bubble wrap (shoulders of bottles must be iced if required) to minimize the possibility of the container breaking.
- If cooling is required (see Attachments A and B), place ice around sample container shoulders, and on top of packing material (minimum of 8 pounds of ice for a medium-size cooler).
- Seal (i.e., tape or tie top in knot) large liner bag.
- The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing the vials for VOC analysis. The COC form should then state how many coolers are included with that shipment.
- Close and seal outside of cooler as described in SOP SA-6.3. Signed custody seals must be used.

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 7 of 11
	Revision 3	Effective Date 02/04

Coolers must be marked as containing "Environmental Samples." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling is required; there are no DOT restrictions on mode of transportation.

## 6.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater, 15th Edition. APHA, Washington, D.C.

International Air Transport Association (latest issue). Dangerous Goods Regulations, Montreal, Quebec, Canada.

U.S. Department of Transportation (latest issue). Hazardous Materials Regulations, 49 CFR 171-177.

U.S. EPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, U.S. EPA-EMSL, Cincinnati, Ohio.

Subject <b>NON-RADIOLOGICAL SAMPLE HANDLING</b>	Number <b>SA-6.1</b>	Page <b>8 of 11</b>
	Revision <b>3</b>	Effective Date <b>02/04</b>

## ATTACHMENT A

### GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS

Sample Type and Concentration	Container <sup>(1)</sup>	Sample Size	Preservation <sup>(2)</sup>	Holding Time <sup>(2)</sup>
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#### WATER

Organics (GC&GC/MS)	VOC	Low	Borosilicate glass	2 x 40 mL	Cool to 4°C HCl to ≤ 2	14 days <sup>(9)</sup>
	Extractables SVOCs and pesticide/PCBs)	(Low	Amber glass	2x2 L or 4x1 L	Cool to 4°C	7 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticide/PCBs)	(Medium	Amber glass	2x2 L or 4x1 L	None	7 days to extraction; 40 days after extraction
Inorganics	Metals	Low	High-density polyethylene	1 L	HNO <sub>3</sub> to pH ≤ 2	6 months (Hg-28 days)
		Medium	Wide-mouth glass	16 oz.	None	6 months
	Cyanide	Low	High-density polyethylene	1 L	NaOH to pH > 12	14 days
	Cyanide	Medium	Wide-mouth glass	16 oz.	None	14 days
Organic/ Inorganic	High Hazard		Wide-mouth glass	8 oz.	None	14 days

#### SOIL

Organics (GC&GC/MS)	VOC		EnCore Sampler	(3) 5 g Samplers	Cool to 4°C	48 hours to lab preservation
	Extractables SVOCs and pesticides/PCBs)	(Low	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticides/PCBs)	(Medium	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
Inorganics	Low/Medium		Wide-mouth glass	8 oz.	Cool to 4°C	6 months (Hg - 28 days) Cyanide (14 days)
Organic/Inorga nic	High Hazard		Wide-mouth glass	8 oz.	None	NA
Dioxin/Furan	All		Wide-mouth glass	4 oz.	None	35 days until extraction; 40 days after extraction
TCLP	All		Wide-mouth glass	8 oz.	None	7 days until preparation; analysis as per fraction

#### AIR

Volatile Organics	Low/Medium	Charcoal tube -- 7 cm long, 6 mm OD, 4 mm ID	100 L air	Cool to 4°C	5 days recommended
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1 All glass containers should have Teflon cap liners or septa.

2 See Attachment E. Preservation and maximum holding time allowances per 40 CFR 136.



Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 9 of 11
	Revision 3	Effective Date 02/04

## ATTACHMENT B

### ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

Parameter Number/Name	Container <sup>(1)</sup>	Preservation <sup>(2)(3)</sup>	Maximum Holding Time <sup>(4)</sup>
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#### INORGANIC TESTS:

Acidity	P, G	Cool, 4°C	14 days
Alkalinity	P, G	Cool, 4°C	14 days
Ammonia - Nitrogen	P, G	Cool, 4°C; H <sub>2</sub> SO <sub>4</sub> to pH 2	28 days
Biochemical Oxygen Demand (BOD)	P, G	Cool, 4°C	48 hours
Bromide	P, G	None required	28 days
Chemical Oxygen Demand (COD)	P, G	Cool, 4°C; H <sub>2</sub> SO <sub>4</sub> to pH 2	28 days
Chloride	P, G	None required	28 days
Chlorine, Total Residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	P, G	Cool, 4°C; NaOH to pH 12; 0.6 g ascorbic acid <sup>(5)</sup>	14 days <sup>(6)</sup>
Fluoride	P	None required	28 days
Hardness	P, G	HNO <sub>3</sub> to pH 2; H <sub>2</sub> SO <sub>4</sub> to pH 2	6 months
Total Kjeldahl and Organic Nitrogen	P, G	Cool, 4°C; H <sub>2</sub> SO <sub>4</sub> to pH 2	28 days
Nitrate - Nitrogen	P, G	None required	48 hours
Nitrate-Nitrite - Nitrogen	P, G	Cool, 4°C; H <sub>2</sub> SO <sub>4</sub> to pH 2	28 days
Nitrite - Nitrogen	P, G	Cool, 4°C	48 hours
Oil & Grease	G	Cool, 4°C; H <sub>2</sub> SO <sub>4</sub> to pH 2	28 days
Total Organic Carbon (TOC)	P, G	Cool, 4°C; HCl or H <sub>2</sub> SO <sub>4</sub> to pH 2	28 days
Orthophosphate	P, G	Filter immediately; Cool, 4°C	48 hours
Oxygen, Dissolved-Probe	G Bottle & top	None required	Analyze immediately
Oxygen, Dissolved-Winkler	G Bottle & top	Fix on site and store in dark	8 hours
Phenols	G	Cool, 4°C; H <sub>2</sub> SO <sub>4</sub> to pH 2	28 days
Phosphorus, Total	P, G	Cool, 4°C; H <sub>2</sub> SO <sub>4</sub> to pH 2	28 days
Residue, Total	P, G	Cool, 4°C	7 days
Residue, Filterable (TDS)	P, G	Cool, 4°C	7 days
Residue, Nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, Settleable	P, G	Cool, 4°C	48 hours
Residue, Volatile (Ash Content)	P, G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific Conductance	P, G	Cool, 4°C	28 days
Sulfate	P, G	Cool, 4°C	28 days

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 10 of 11
	Revision 3	Effective Date 02/04

**ATTACHMENT B**  
**ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES,**  
**AND HOLDING TIMES**  
**PAGE TWO**

Parameter Number/Name	Container <sup>(1)</sup>	Preservation <sup>(2)(3)</sup>	Maximum Holding Time <sup>(4)</sup>
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**INORGANIC TESTS (Cont'd):**

Sulfide	P, G	Cool, 4°C; add zinc acetate plus sodium hydroxide to pH 9	7 days
Sulfite	P, G	None required	Analyze immediately
Turbidity	P, G	Cool, 4°C	48 hours

**METALS:<sup>(7)</sup>**

Chromium VI (Hexachrome)	P, G	Cool, 4°C	24 hours
Mercury (Hg)	P, G	HNO <sub>3</sub> to pH 2	28 days
Metals, except Chromium VI and Mercury	P, G	HNO <sub>3</sub> to pH 2	6 months

**ORGANIC TESTS:<sup>(8)</sup>**

Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> <sup>(5)</sup>	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> <sup>(5)</sup> HCl to pH 2 <sup>(9)</sup>	14 days
Acrolein and Acrylonitrile	G, Teflon-lined septum	Cool, 4°C; 0.008% Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> <sup>(5)</sup> adjust pH to 4-5 <sup>(10)</sup>	14 days
Phenols <sup>(11)</sup>	G, Teflon-lined cap	Cool, 4°C; 0.008% Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> <sup>(5)</sup>	7 days until extraction; 40 days after extraction
Benzidines <sup>(11), (12)</sup>	G, Teflon-lined cap	Cool, 4°C; 0.008% Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> <sup>(5)</sup>	7 days until extraction <sup>(13)</sup>
Phthalate esters <sup>(11)</sup>	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitrosamines <sup>(11), (14)</sup>	G, Teflon-lined cap	Cool, 4°C; store in dark; 0.008% Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> <sup>(5)</sup>	7 days until extraction; 40 days after extraction
PCBs <sup>(11)</sup>	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitroaromatics & Isophorone <sup>(11)</sup>	G, Teflon-lined cap	Cool, 4°C; 0.008% Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> <sup>(5)</sup> ; store in dark	7 days until extraction; 40 days after extraction
Polynuclear Aromatic Hydrocarbons (PAHs) <sup>(11), (14)</sup>	G, Teflon-lined cap	Cool, 4°C; 0.008% Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> <sup>(5)</sup> ; store in dark	7 days until extraction; 40 days after extraction
Haloethers <sup>(11)</sup>	G, Teflon-lined cap	Cool, 4°C; 0.008% Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> <sup>(5)</sup>	7 days until extraction; 40 days after extraction
Dioxin/Furan (TCDD/TCDF) <sup>(11)</sup>	G, Teflon-lined cap	Cool, 4°C; 0.008% Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> <sup>(5)</sup>	7 days until extraction; 40 days after extraction

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 11 of 11
	Revision 3	Effective Date 02/04

**ATTACHMENT B**  
**ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES,**  
**AND HOLDING TIMES**  
**PAGE THREE**

- (1) Polyethylene (P): generally 500 ml or Glass (G): generally 1L.
- (2) Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.
- (3) When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172).
- (4) Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer periods, and has received a variance from the Regional Administrator.
- (5) Should only be used in the presence of residual chlorine.
- (6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments are made to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.
- (7) Samples should be filtered immediately on site before adding preservative for dissolved metals.
- (8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.
- (9) Sample receiving no pH adjustment must be analyzed within 7 days of sampling.
- (10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.
- (11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for 7 days before extraction and for 40 days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12, 13 (re: the analysis of benzidine).
- (12) If 1,2-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0±0.2 to prevent rearrangement to benzidine.
- (13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.
- (14) For the analysis of diphenylnitrosamine, add 0.008% Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> and adjust pH to 7-10 with NaOH within 24 hours of sampling.
- (15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>.



TETRA TECH NUS, INC.

# STANDARD OPERATING PROCEDURES

Number

SA-6.3

Page

1 of 12

Effective Date

09/03

Revision

2

Applicability

Tetra Tech NUS, Inc.

Prepared

Earth Sciences Department

Subject

FIELD DOCUMENTATION

Approved

D. Senovich *DS*

## TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 PURPOSE.....	2
2.0 SCOPE.....	2
3.0 GLOSSARY .....	2
4.0 RESPONSIBILITIES .....	2
5.0 PROCEDURES .....	2
5.1 SITE LOGBOOK .....	2
5.1.1 General.....	2
5.1.2 Photographs .....	3
5.2 FIELD NOTEBOOKS .....	3
5.3 FIELD FORMS .....	4
5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results..	4
5.3.2 Hydrogeological and Geotechnical Forms .....	5
5.3.3 Equipment Calibration and Maintenance Form .....	6
5.4 FIELD REPORTS.....	6
5.4.1 Daily Activities Report.....	6
5.4.2 Weekly Status Reports.....	7
6.0 LISTING OF TETRA TECH NUS FIELD FORMS FOUND ON THE TTNUS INTRANET SITE. <a href="http://intranet.ttnus.com">HTTP://INTRANET.TTNUS.COM</a> CLICK ON FIELD LOG SHEETS.....	7

## ATTACHMENTS

A	TYPICAL SITE LOGBOOK ENTRY .....	9
B	SAMPLE LABEL.....	10
C	CHAIN-OF-CUSTODY RECORD FORM.....	11
D	CHAIN-OF-CUSTODY SEAL .....	12

Subject  FIELD DOCUMENTATION	Number SA-6.3	Page 2 of 12
	Revision 2	Effective Date 09/03

## 1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs and reports generally initiated and maintained for documenting Tetra Tech NUS field activities.

## 2.0 SCOPE

Documents presented within this procedure (or equivalents) shall be used for all Tetra Tech NUS field activities, as applicable. Other or additional documents may be required by specific client contracts or project planning documents.

## 3.0 GLOSSARY

None

## 4.0 RESPONSIBILITIES

Project Manager (PM) - The Project Manager is responsible for obtaining hardbound, controlled-distribution logbooks (from the appropriate source), as needed. In addition, the Project Manager is responsible for placing all field documentation used in site activities (i.e., records, field reports, sample data sheets, field notebooks, and the site logbook) in the project's central file upon the completion of field work.

Field Operations Leader (FOL) - The Field Operations Leader is responsible for ensuring that the site logbook, notebooks, and all appropriate and current forms and field reports illustrated in this guideline (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time-frame.

## 5.0 PROCEDURES

### 5.1 Site Logbook

#### 5.1.1 General

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major onsite activities are documented. At a minimum, the following activities/events shall be recorded or referenced (daily) in the site logbook:

- All field personnel present
- Arrival/departure of site visitors
- Time and date of H&S training
- Arrival/departure of equipment
- Time and date of equipment calibration
- Start and/or completion of borehole, trench, monitoring well installation, etc.
- Daily onsite activities performed each day
- Sample pickup information
- Health and Safety issues (level of protection observed, etc.)
- Weather conditions

A site logbook shall be maintained for each project. The site logbook shall be initiated at the start of the first onsite activity (e.g., site visit or initial reconnaissance survey). Entries are to be made for every day

Subject  FIELD DOCUMENTATION	Number SA-6.3	Page 3 of 12
	Revision 2	Effective Date 09/03

that onsite activities take place which involve Tetra Tech NUS or subcontractor personnel. Upon completion of the fieldwork, the site logbook must become part of the project's central file.

The following information must be recorded on the cover of each site logbook:

- Project name
- Tetra Tech NUS project number
- Sequential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2), but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the field notebook in which the measurements are recorded (see Attachment A).

All logbook, notebook, and log sheet entries shall be made in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, the entry shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook pages used must be signed and dated. The site logbook must also be signed by the Field Operations Leader at the end of each day.

#### **5.1.2 Photographs**

When movies, slides, or photographs are taken of a site or any monitoring location, they must be numbered sequentially to correspond to logbook/notebook entries. The name of the photographer, date, time, site location, site description, and weather conditions must be entered in the logbook/notebook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook/notebook. If possible, such techniques shall be avoided, since they can adversely affect the accuracy of photographs. Chain-of-custody procedures depend upon the subject matter, type of camera (digital or film), and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Once processed, the slides of photographic prints shall be consecutively numbered and labeled according to the logbook/notebook descriptions. The site photographs and associated negatives and/or digitally saved images to compact disks must be docketed into the project's central file.

#### **5.2 Field Notebooks**

Key field team personnel may maintain a separate dedicated field notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the Health and Safety Officer may elect to maintain a separate field notebook. Where several drill rigs are in operation simultaneously, each site geologist assigned to oversee a rig must maintain a field notebook.

Subject  FIELD DOCUMENTATION	Number SA-6.3	Page 4 of 12
	Revision 2	Effective Date 09/03

### 5.3 **Field Forms**

All Tetra Tech NUS field forms (see list in Section 6.0 of this SOP) can be found on the company's intranet site (<http://intranet.ttnus.com>) under Field Log Sheets. Forms may be altered or revised for project-specific needs contingent upon client approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOP.

#### 5.3.1 **Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results**

##### 5.3.1.1 Sample Log Sheet

Sample Log Sheets are used to record specified types of data while sampling. The data recorded on these sheets are useful in describing the sample as well as pointing out any problems, difficulties, or irregularities encountered during sampling. A log sheet must be completed for each sample obtained, including field quality control (QC) samples.

##### 5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B. Adhesive labels must be completed and applied to every sample container. Sample labels can usually be obtained from the appropriate Program source electronically generated in-house, or are supplied from the laboratory subcontractor.

##### 5.3.1.3 Chain-of-Custody Record Form

The Chain-of-Custody (COC) Record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site. One carbonless copy of the completed COC form is retained by the field crew, one copy is sent to the Project Manager (or designee), while the original is sent to the laboratory. The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing vials for VOC analysis or the cooler with the air bill attached. The air bill should then state how many coolers are included with that shipment. An example of a Chain-of-Custody Record form is provided as Attachment C. Once the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed COC form (any discrepancies between the sample labels and COC form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the Tetra Tech NUS Project Manager). The COC form is signed and copied. The laboratory will retain the copy while the original becomes part of the samples' corresponding analytical data package.

##### 5.3.1.4 Chain-of-Custody Seal

Attachment D is an example of a custody seal. The Custody seal is an adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transport to the laboratory. The COC seals are signed and dated by the sampler(s) and affixed across the lid and body of each cooler (front and back) containing environmental samples (see SOP SA-6.1). COC seals may be available from the laboratory; these seals may also be purchased from a supplier.



Subject  FIELD DOCUMENTATION	Number SA-6.3	Page 5 of 12
	Revision 2	Effective Date 09/03

#### 5.3.1.5 Geochemical Parameters Log Sheets

Field Analytical Log Sheets are used to record geochemical and/or natural attenuation field test results.

### 5.3.2 **Hydrogeological and Geotechnical Forms**

#### 5.3.2.1 Groundwater Level Measurement Sheet

A Groundwater Level Measurement Sheet must be filled out for each round of water level measurements made at a site.

#### 5.3.2.2 Data Sheet for Pumping Test

During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. The Pumping Test Data Sheet facilitates this task by standardizing the data collection format for the pumping well and observation wells, and allowing the time interval for collection to be laid out in advance.

#### 5.3.2.3 Packer Test Report Form

A Packer Test Report Form must be completed for each well upon which a packer test is conducted.

#### 5.3.2.4 Boring Log

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Summary Log of Boring, or Boring Log is used for this purpose and must be completed for each soil boring performed. In addition, if volatile organics are monitored on cores, samples, cuttings from the borehole, or breathing zone, (using a PID or FID), these readings must be entered on the boring log at the appropriate depth. The "Remarks" column can be used to subsequently enter the laboratory sample number, the concentration of key analytical results, or other pertinent information. This feature allows direct comparison of contaminant concentrations with soil characteristics.

#### 5.3.2.5 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock, stick-up or flush mount), different forms are used.

#### 5.3.2.6 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician.

Subject  FIELD DOCUMENTATION	Number SA-6.3	Page 6 of 12
	Revision 2	Effective Date 09/03

#### 5.3.2.7 Miscellaneous Monitoring Well Forms

Monitoring Well Materials Certificate of Conformance should be used as the project directs to document all materials utilized during each monitoring well installation.

The Monitoring Well Development Record should be used as the project directs to document all well development activities.

#### 5.3.2.8 Miscellaneous Field Forms - QA and Checklists

Container Sample and Inspection Sheet should be used as the project directs each time a container (drum, tank, etc.) is sampled and/or inspected.

QA Sample Log Sheet should be used at the project directs each time a QA sample is collected, such as Rinsate Blank, Source Blank, etc.

Field Task Modification Request (FTMR) will be prepared for all deviations from the project planning documents. The FOL is responsible for initiating the FTMRs. Copies of all FTMRs will be maintained with the onsite planning documents and originals will be placed in the final evidence file.

The Field Project Daily Activities Check List and Field Project Pre-Mobilization Checklist should be used during both the planning and field effort to assure that all necessary tasks are planned for and completed. These two forms are not a requirement but a useful tool for most field work.

### 5.3.3 **Equipment Calibration and Maintenance Form**

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. An Equipment Calibration Log must be maintained for each electronic measuring device used in the field; entries must be made for each day the equipment is used or in accordance with the manufacturer's recommendations.

## 5.4 Field Reports

The primary means of recording onsite activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation, but are not easily useful for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain onsite for extended periods of time and are thus not accessible for timely review by project management.

### 5.4.1 **Daily Activities Report**

To provide timely oversight of onsite contractors, Daily Activities Reports are completed and submitted as described below.

Subject  FIELD DOCUMENTATION	Number SA-6.3	Page 7 of 12
	Revision 2	Effective Date 09/03

#### 5.4.1.1 Description

The Daily Activities Report (DAR) documents the activities and progress for each day's field work. This report must be filled out on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring which involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors. The DAR form can be found on the TtNUS intranet site.

#### 5.4.1.2 Responsibilities

It is the responsibility of the rig geologist to complete the DAR and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

#### 5.4.1.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the Daily Activities Report to the Field Operations Leader (FOL) for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The DAR reports are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the Project Manager.

### 5.4.2 **Weekly Status Reports**

To facilitate timely review by project management, photocopies of logbook/notebook entries may be made for internal use.

It should be noted that in addition to summaries described herein, other summary reports may also be contractually required.

All Tetra Tech NUS field forms can be found on the company's intranet site at <http://intranet.ttnus.com> under Field Log Sheets.

### 6.0 **LISTING OF TETRA TECH NUS FIELD FORMS FOUND ON THE TTNUS INTRANET SITE. HTTP://INTRANET.TTNUS.COM CLICK ON FIELD LOG SHEETS**

Groundwater Sample Log Sheet  
Surface Water Sample Log Sheet  
Soil/Sediment Sample Log Sheet  
Container Sample and Inspection Sheet  
Geochemical Parameters (Natural Attenuation)  
Groundwater Level Measurement Sheet  
Pumping Test Data Sheet  
Packer Test Report Form  
Boring Log  
Monitoring Well Construction Bedrock Flush Mount  
Monitoring Well Construction Bedrock Open Hole  
Monitoring Well Construction Bedrock Stick Up  
Monitoring Well Construction Confining Layer  
Monitoring Well Construction Overburden Flush Mount  
Monitoring Well Construction Overburden Stick Up  
Test Pit Log  
Monitoring Well Materials Certificate of Conformance  
Monitoring Well Development Record

Subject  FIELD DOCUMENTATION	Number SA-6.3	Page 8 of 12
	Revision 2	Effective Date 09/03

Daily Activities Record  
 Field Task Modification Request  
 Hydraulic Conductivity Test Data Sheet  
 Low Flow Purge Data Sheet  
 QA Sample Log Sheet  
 Equipment Calibration Log  
 Field Project Daily Activities Checklist  
 Field Project Pre-Mobilization Checklist

Subject  FIELD DOCUMENTATION	Number SA-6.3	Page 9 of 12
	Revision 2	Effective Date 09/03

**ATTACHMENT A  
TYPICAL SITE LOGBOOK ENTRY**

START TIME: \_\_\_\_\_ DATE: \_\_\_\_\_

SITE LEADER: \_\_\_\_\_

PERSONNEL: \_\_\_\_\_

TtNUS

DRILLER

SITE VISITORS

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

WEATHER: Clear, 68°F, 2-5 mph wind from SE


ACTIVITIES:

1. Steam jenny and fire hoses were set up.
2. Drilling activities at well \_\_\_\_ resumes. Rig geologist was \_\_\_\_\_. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4-inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well \_\_\_\_\_.
3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well \_\_\_\_\_.
4. Well \_\_\_\_\_ drilled. Rig geologist was \_\_\_\_\_. See Geologist's Notebook, No. 2, page \_\_\_\_ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5. Well \_\_\_\_\_ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6. EPA remedial project manager arrives on site at 14:25 hours.
7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit \_\_\_\_\_.
8. Test pit \_\_\_\_\_ dug with cuttings placed in dump truck. Rig geologist was \_\_\_\_\_. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit \_\_\_\_ resulted in a very soft and wet area. A mound was developed and the area roped off.
9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel off site, gate locked.

\_\_\_\_\_  
Field Operations Leader

Subject  FIELD DOCUMENTATION	Number SA-6.3	Page 10 of 12
	Revision 2	Effective Date 09/03

### ATTACHMENT B

	Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090		Project:
			Site:
		Location:	
Sample No:			Matrix:
Date:	Time:	Preserve:	
Analysis:			
Sampled by:		Laboratory:	



TETRA TECH NUS, INC.

CHAIN OF CUSTODY

NUMBER 3413

PAGE \_\_\_\_ OF \_\_\_\_

PROJECT NO:		FACILITY:		PROJECT MANAGER		PHONE NUMBER		LABORATORY NAME AND CONTACT:	
SAMPLERS (SIGNATURE)				FIELD OPERATIONS LEADER		PHONE NUMBER		ADDRESS	
				CARRIER/WAYBILL NUMBER				CITY, STATE	
STANDARD TAT <input type="checkbox"/> RUSH TAT <input type="checkbox"/> <input type="checkbox"/> 24 hr. <input type="checkbox"/> 48 hr. <input type="checkbox"/> 72 hr. <input type="checkbox"/> 7 day <input type="checkbox"/> 14 day				TOP DEPTH (FT)	BOTTOM DEPTH (FT)	MATRIX (GW, SO, SW, SD, QC, ETC.)	COLLECTION METHOD GRAP (G) COMP (C)	No. OF CONTAINERS	CONTAINER TYPE PLASTIC (P) or GLASS (G)
DATE YEAR	TIME	SAMPLE ID	LOCATION ID						PRESERVATIVE USED
					<div style="text-align: center;"> <b>TYPE OF ANALYSIS</b>    <b>COMMENTS</b> </div>				
1. RELINQUISHED BY				DATE					
2. RELINQUISHED BY				DATE	TIME	2. RECEIVED BY		DATE	TIME
3. RELINQUISHED BY				DATE	TIME	3. RECEIVED BY		DATE	TIME
COMMENTS									

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE)

YELLOW (FIELD COPY)

PINK (FILE COPY)

4/02R  
FORM NO. TINUS-001

## ATTACHMENT C

## FIELD DOCUMENTATION

Subject	Number	Page
	SA-6.3	11 of 12
Revision	2	Effective Date
		09/03

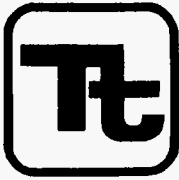


Subject  FIELD DOCUMENTATION	Number SA-6.3	Page 12 of 12
	Revision 2	Effective Date 09/03

ATTACHMENT D

CHAIN-OF-CUSTODY SEAL

<b>Signature</b> <hr/>		<b>CUSTODY SEAL</b>
<b>Date</b> <hr/>		<b>Date</b> <hr/>
<b>CUSTODY SEAL</b>		<b>Signature</b> <hr/>



TETRA TECH NUS, INC.

# STANDARD OPERATING PROCEDURES

Number  
CT-04

Page  
1 of 6

Effective Date  
09/03

Revision  
1

Applicability  
Tetra Tech NUS, Inc.

Prepared  
Risk Assessment Department

Subject  
SAMPLE NOMENCLATURE

Approved  
D. Senovich *DS*

## TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 PURPOSE.....	2
2.0 SCOPE.....	2
3.0 GLOSSARY .....	2
4.0 RESPONSIBILITIES.....	2
5.0 PROCEDURES.....	2
5.1 INTRODUCTION.....	2
5.2 SAMPLE IDENTIFICATION FIELD REQUIREMENTS.....	3
5.3 EXAMPLE SAMPLE FIELD DESIGNATIONS .....	4
5.4 EXAMPLES OF SAMPLE NOMENCLATURE .....	5
5.5 FIELD QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) SAMPLE NOMENCLATURE).....	6
5.6 EXAMPLES OF FIELD QA/QC SAMPLE NOMENCLATURE .....	6
6.0 DEVIATIONS .....	6

Subject  SAMPLE NOMENCLATURE	Number CT-04	Page 2 of 6
	Revision 1	Effective Date 09/03

## 1.0 PURPOSE

The purpose of this document is to specify a consistent sample nomenclature system that will facilitate subsequent data management in a cost-effective manner. The sample nomenclature system has been devised such that the following objectives can be attained:

- Sorting of data by matrix.
- Sorting of data by depth.
- Maintenance of consistency (field, laboratory, and data base sample numbers).
- Accommodation of all project-specific requirements.
- Accommodation of laboratory sample number length constraints (maximum of 20 characters).

## 2.0 SCOPE

The methods described in this procedure shall be used consistently for all projects requiring electronic data.

## 3.0 GLOSSARY

None.

## 4.0 RESPONSIBILITIES

**Program Manager** - It shall be the responsibility of the Program Manager (or designee) to inform contract-specific Project Managers of the existence and requirements of this Standard Operating Procedure.

**Project Manager** - It shall be the responsibility of the Project Manager to determine the applicability of this Standard Operating Procedure based on: (1) program-specific requirements, and (2) project size and objectives. It shall be the responsibility of the Project Manager (or designee) to ensure that the sample nomenclature is thoroughly specified in the relevant project planning document (e.g., sampling and analysis plan) and is consistent with this Standard Operating Procedure if relevant. It shall be the responsibility of the project manager to ensure that the Field Operations Leader is familiar with the sample nomenclature system.

**Field Operations Leader** - It shall be the responsibility of the Field Operations Leader to ensure that all field technicians or sampling personnel are thoroughly familiar with this Standard Operating Procedure and the project-specific sample nomenclature system. It shall be the responsibility of the Field Operations Leader to ensure that the sample nomenclature system is used during all project-specific sampling efforts.

## 5.0 PROCEDURES

### 5.1 Introduction

The sample identification (ID) system can consist of as few as 8 but not more than 20 distinct alphanumeric characters. The sample ID will be provided to the laboratory on the sample labels and chain-of-custody forms. The basic sample ID provided to the lab has three segments and shall be as follows where "A" indicates "alpha," and "N" indicates "numeric":

A or N 3- or 4-Characters	AAA 2- or 3-Characters	A or N 3- to 6-Characters
Site Identifier	Sample Type	Sample Location

Subject  SAMPLE NOMENCLATURE	Number CT-04	Page 3 of 6
	Revision 1	Effective Date 09/03

Additional segments may be added as needed. For example:

(1) Soil and Sediment Sample ID

<b>A or N</b> <b>3- or 4-Characters</b>	<b>AAA</b> <b>2- or 3-Characters</b>	<b>A or N</b> <b>3- to 6-Characters</b>	<b>NNNN</b> <b>4-Characters</b>
Site Identifier	Sample Type	Sample Location	Sample Depth

(2) Aqueous (groundwater or surface water) Sample ID

<b>A or N</b> <b>3- or 4-Characters</b>	<b>AAA</b> <b>2- or 3-Characters</b>	<b>A or N</b> <b>3- to 6-Characters</b>	<b>NN</b> <b>2-Characters</b>	<b>-A</b>
Site Identifier	Sample type	Sample Location	Round Number	Filtered Sample only

(3) Biota Sample ID

<b>A or N</b> <b>3- or 4-Characters</b>	<b>AAA</b> <b>2- or 3-Characters</b>	<b>A or N</b> <b>3- to 6-Characters</b>	<b>AA</b> <b>2-Characters</b>	<b>NNN</b> <b>3-Characters</b>
Site Identifier	Sample Type	Sample Location	Species Identifier	Sample Group Number

## 5.2 Sample Identification Field Requirements

The various fields in the sample ID will include but are not limited to the following:

- Site Identifier
- Sample Type
- Sample Location
- Sample Depth
- Sampling Round Number
- Filtered
- Species Identifier
- Sample Group Number

The site identifier must be a three- or four-character field (numeric characters, alpha characters, or a mixture of alpha and numeric characters may be used). A site number is necessary since many facilities/sites have multiple individual sites, SWMUs, operable units, etc. Several examples are presented in Section 5.3 of this SOP.

The sample type must be a two- or three-character alpha field. Suggested codes are provided in Section 5.3 of this SOP.

The sample location must be at least a three-character field but may have up to six-characters (alpha, numeric, or a mixture). The six-characters may be useful in identifying a monitoring well to be sampled or describing a grid location.

The sample depth field is used to note the depth below ground surface (bgs) at which a soil or sediment sample is collected. The first two numbers of the four-number code specify the top interval, and the third and fourth specify the bottom interval in feet bgs of the sample. If the sample depth is equal to or greater than 100, then only the top interval would be represented and the sampling depth would be truncated to

Subject  SAMPLE NOMENCLATURE	Number CT-04	Page 4 of 6
	Revision 1	Effective Date 09/03

three-characters. The depths will be noted in whole numbers only; further detail, if needed, will be recorded on the sample log sheet, boring log, logbook, etc.

A two-digit round number will be used to track the number of aqueous samples taken from a particular aqueous sample location. The first sample collected from a location will be assigned the round identifier 01, the second 02, etc. This applies to both existing and proposed monitoring wells and surface water locations.

Aqueous samples that are field filtered (dissolved analysis) will be identified with an "-F" in the last field segment. No entry in this segment signifies an unfiltered (total) sample.

The species identifier must be a two-character alpha field. Several suggested codes are provided in Section 5.3 of this SOP.

The three digit sample group number will be used to track the number of biota sample groups (a particular group size may be determined by sample technique, media type, the number of individual caught, weight issues, time, etc.) by species and location. The first sample group of a particular species collected from a given location will be assigned the sample group number 001 and the second sample group of the same species collected from the same location will be assigned the sample group number 002.

### 5.3 Example Sample Field Designations

Examples of each of the fields are as follows:

Site Identifier - Examples of site numbers/designations are as follows:

A01 - Area of Concern Number 1  
125 - Solid Waste Management Unit Number 125  
000 - Base or Facility Wide Sample (e.g., upgradient well)  
BBG - Base Background

The examples cited are only suggestions. Each Project Manager (or designee) must designate appropriate (and consistent) site designations for their individual project.

Sample Type - Examples of sample types are as follows:

AH - Ash Sample  
AS - Air Sample  
BM - Building Material Sample  
BSB - Biota Sample Full Body  
BSF - Biota Sample Fillet  
CP - Composite Sample  
CS - Chip Sample  
DS - Drum Sample  
DU - Dust Sample  
FP - Free Product  
IDW - Investigation Derived Waste Sample  
LT - Leachate Sample  
MW - Monitoring Well Groundwater Sample  
OF - Outfall Sample  
RW - Residential Well Sample  
SB - Soil Boring Sample  
SD - Sediment Sample  
SC - Scrape Sample

Subject  SAMPLE NOMENCLATURE	Number CT-04	Page 5 of 6
	Revision 1	Effective Date 09/03

SG - Soil Gas Sample  
 SL - Sludge Sample  
 SP - Seep Sample  
 SS - Surface Soil Sample  
 ST - Storm Sewer Water Sample  
 SW - Surface Water Sample  
 TP - Test Pit Sample  
 TW - Temporary Well Sample  
 WC - Well Construction Material Sample  
 WP - Wipe Sample  
 WS - Waste/Solid Sample  
 WW - Wastewater Sample

Sample Location - Examples of the location field are as follows:

001 - Monitoring Well 1  
 N32E92 - Grid location 32 North and 92 East  
 D096 - Investigation derived waste drum number 96

Species Identifier - Examples of species identifier are as follows:

BC - Blue Crab  
 GB - Blue Gill  
 CO - Corn  
 SB - Soybean

#### 5.4 Examples of Sample Nomenclature

The first round monitoring well groundwater sample collected from existing monitoring well 001 at SWMU 16 for a filtered sample would be designated as 016MW00101-F.

The second round monitoring well groundwater sample collected from existing monitoring well C20P2 at Site 23 for an unfiltered sample would be designated as 023MWC20P202.

The second surface water sample collected from point 01 at SWMU 130 for an unfiltered sample would be designated as 130SW00102.

A surface soil sample collected from grid location 32 North and 92 East at Site 32 at the 0- to 2-foot interval would be designated as 032SSN32E920002.

A subsurface soil sample from soil boring 03 at SWMU 32 at an interval of 4 to 5 feet bgs would be designated as 032SB0030405.

A sediment sample collected at SWMU 19 from 0 to 6 inches at location 14 would be designated as 019SD0140001. The sample data sheet would reflect the precise depth at which this sample was collected.

During biota sampling for full body analysis the first time a minnow trap was checked at grid location A25 of SWMU 1415 three small blue gills were captured, collected and designated with the sample ID of 1415BSBA25BG001. The second time blue gill were collected at the same location (grid location A25 at SWMU 1415) the sample ID designation given was 1415BSBA25BG002.

Note: No dash (-) or spacing is used between the segments with the exception of the filtered segment. The "F" used for a filtered aqueous sample is preceded by a dash "-F".

Subject  SAMPLE NOMENCLATURE	Number CT-04	Page 6 of 6
	Revision 1	Effective Date 09/03

### 5.5 Field Quality Assurance/Quality Control (QA/QC) Sample Nomenclature)

Field QA/QC will be designated using a different coding system. The QC code will consist of a three- to four-segment alpha-numeric code that identifies the sample QC type, the date the sample was collected, and the number of this type of QC sample collected on that date.

AA	NNNNNN	NN	-F
QC Type	Date	Sequence Number (per day)	Filtered (aqueous only, if needed)

The QC types are identified as:

TB = Trip Blank  
RB = Rinsate Blank (Equipment Blank)  
FD = Field Duplicate  
AB = Ambient Conditions Blank  
WB = Source Water Blank

The sampling time recorded on the Chain-of-Custody Form, labels, and tags for duplicate samples will be 0000 so that the samples are "blind" to the laboratory. Notes detailing the sample number, time, date, and type will be recorded on the routine sample log sheets and will document the location of the duplicate sample (sample log sheets are not provided to the laboratory). Documentation for all other QC types (TB, RB, AB, and WB) will be recorded on the QC Sample Log sheet (see SOP on Field Documentation).

### 5.6 Examples of Field QA/QC Sample Nomenclature

The first duplicate of the day for a filtered ground water sample collected on June 3, 2000 would be designated as FD06030001-F.

The third duplicate of the day taken of a subsurface soil sample collected on November 17, 2003 would be designated as FD11170303.

The first trip blank associated with samples collected on October 12, 2000 would be designated as TB10120001.

The only rinsate blank collected on November 17, 2001 would be designated as RB11170101.

### 6.0 **DEVIATIONS**

Any deviation from this SOP must be addressed in detail in the site specific planning documents.

## **APPENDIX C**

### **FIELD DATA COLLECTION SHEETS**





Tetra Tech NUS, Inc.

## DAILY ACTIVITIES RECORD

PROJECT NAME: \_\_\_\_\_ PROJECT NUMBER: \_\_\_\_\_  
CLIENT: \_\_\_\_\_ LOCATION: \_\_\_\_\_  
DATE: \_\_\_\_\_ ARRIVAL TIME: \_\_\_\_\_  
Tt NUS PERSONNEL: \_\_\_\_\_ DEPARTURE TIME: \_\_\_\_\_  
CONTRACTOR: \_\_\_\_\_ DRILLER: \_\_\_\_\_

ITEM	QUANTITY ESTIMATE	QUANTITY TODAY	PREVIOUS TOTAL QUANTITY	CUMULATIVE QUANTITY TO DATE

COMMENTS: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

APPROVED BY: \_\_\_\_\_

\_\_\_\_\_  
Tt NUS REPRESENTATIVE

\_\_\_\_\_  
DRILLER

DATE: \_\_\_\_\_



**Project Name:** \_\_\_\_\_ **Project No.:** \_\_\_\_\_  
**Location:** \_\_\_\_\_ **Personnel:** \_\_\_\_\_  
**Weather Conditions:** \_\_\_\_\_ **Measuring Device:** \_\_\_\_\_  
**Tidally Influenced:** Yes \_\_\_\_ No \_\_\_\_ **Remarks:** \_\_\_\_\_

\* All measurements to the nearest 0.01 foot



## GROUNDWATER SAMPLE LOG SHEET

Page \_\_\_ of \_\_\_

Project Site Name: \_\_\_\_\_

Project No.: \_\_\_\_\_

- ☐ Domestic Well Data  
☐ Monitoring Well Data  
☐ Other Well Type: \_\_\_\_\_  
☐ QA Sample Type: \_\_\_\_\_

Sample ID No.: \_\_\_\_\_

Sample Location: \_\_\_\_\_

Sampled By: \_\_\_\_\_

C.O.C. No.: \_\_\_\_\_

Type of Sample: \_\_\_\_\_

☐ Low Concentration☐ High Concentration

## SAMPLING DATA:

Date:	Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Time:	(Visual)	(S.U.)	(mS/cm)	(°C)	(NTU)	(mg/l)	(%)	
Method:								

## PURGE DATA:

Date:	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Method:								
Monitor Reading (ppm):								
Well Casing Diameter & Material								
Type:								
Total Well Depth (TD):								
Static Water Level (WL):								
One Casing Volume(gal/L):								
Start Purge (hrs):								
End Purge (hrs):								
Total Purge Time (min):								
Total Vol. Purged (gal/L):								

## SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

## OBSERVATIONS / NOTES:

--

Circle if Applicable:

MS/MSD

Duplicate ID No.: \_\_\_\_\_

Signature(s): \_\_\_\_\_



## QA SAMPLE LOG SHEET

Page \_\_\_\_ of \_\_\_\_

Project Site Name: _____		Sample ID Number: _____	
Project Number: _____		Sampled By: _____	
Sample Location: _____		C.O.C. Number: _____	
QA Sample Type:			
<input type="checkbox"/> Trip Blank		<input type="checkbox"/> Rinsate Blank	
<input type="checkbox"/> Source Water Blank		<input type="checkbox"/> Other Blank _____	
<b>SAMPLING DATA:</b>		<b>WATER SOURCE:</b>	
Date: _____		<input type="checkbox"/> Laboratory Prepared	
Time: _____		<input type="checkbox"/> Tap	
Method: _____		<input type="checkbox"/> Purchased	
		<input type="checkbox"/> Fire Hydrant	
		<input type="checkbox"/> Other _____	
<b>PURCHASED WATER INFORMATION</b> (If Applicable as Source or Rinsate Water):		<b>RINSATE INFORMATION</b> (If Applicable):	
Product Name: _____		Media Type: _____	
Supplier: _____		Equipment Used: _____	
Manufacturer: _____		Equipment Type:	
Order Number: _____		<input type="checkbox"/> Dedicated	
Lot Number: _____		<input type="checkbox"/> Reusable	
Expiration Date: _____			
<b>SAMPLE COLLECTION INFORMATION:</b>			
Analysis	Preservative	Container Requirements	Collected
<b>OBSERVATIONS / NOTES:</b>			
<b>Signature(s):</b> _____			



## EQUIPMENT CALIBRATION LOG

PROJECT NAME :

INSTRUMENT NAME/MODEL:

SITE NAME: \_\_\_\_\_

MANUFACTURER:

PROJECT No.: \_\_\_\_\_

SERIAL NUMBER: \_\_\_\_\_

[illegible]

## **APPENDIX D**

### **N-BLEND COMPOSITION and ZOD ESTIMATION (CONFIDENTIAL INFORMATION)**

This confidential information was submitted to FDEP on December 18, 2009 and approved by FDEP on February 26, 2010; Appendix D is not to be made available in the public record.

## **APPENDIX E**

### **UIC MEMORANDUM**

TO: Cathy McCarty, P.G.  
Bureau of Water Facilities Regulation  
Underground Injection Control Section – MS 3530

FROM: Mr. Gerry Walker, PG.  
Tetra Tech NUS, Inc.  
558 Village Square Blvd, Ste. 2, Tallahassee, Florida, 32309

DATE: 10/06/2009

SUBJECT: **Proposed Injection(s) for In Situ Aquifer  
Remediation at a Petroleum Remedial Action Site**

Pursuant to paragraph 62-528.630(2)(c), F.A.C., inventory information is hereby provided regarding the proposed construction of temporary injection well(s) for the purpose of in situ aquifer remediation at a petroleum-contaminated site.

Facility name: UST Site 18, NAS Pensacola  
Facility address: 190 Radford Blvd  
City/County: Pensacola, FL 32508-5217  
Latitude/Longitude: E 1078257, N 500233  
FDEP Facility Number: TBD

Facility owner's name: NAVFAC Southeast  
Facility owner's address: EV3 Environmental Restoration  
Naval Air Station Jacksonville  
Jacksonville, Florida 32212

Well contractor's name: Tetra Tech NUS, Inc.  
Well contractor's address: 558 Village Square Blvd, Ste. 2,  
Tallahassee, Florida, 32309



## AFFECTED AQUIFER

Name of aquifer: NA (surface aquifer)  
Depth to groundwater (feet): 2 to 7 feet  
Aquifer thickness (feet): 45 to 80 feet (average 60 feet)  
Areal extent of contamination (square feet): approximately 200,000

## INJECTION WELLS

A site map showing the location and spacing of injection wells, the areal extent of the groundwater contamination plume, and associated monitoring wells is attached. The injection well(s) features are summarized below, and/or a schematic of the injection well(s) is attached. These wells are existing wells.

Direct-push or HSA/Mud rotary (*circle the appropriate well type*)  
Diameter of well(s) (i.e., riser pipe & screen) (inches): 2  
Total depth of well(s) (feet): 18GS28 - 11.5'; 18MW59S - 11.75'  
Screened interval: 1.5 to 11.5 feet below land surface (18GS28)  
Screened interval: 1.75 to 11.75 feet below land surface (18MW59S)  
Grouted interval: NA to NA feet below land surface  
Casing diameter, if applicable (inches): NA  
Cased depth, if applicable: NA to NA feet below land surface  
Casing material, if applicable: PVC

## PROJECT DESCRIPTION

The in situ, injection-type aquifer remediation product/process remediates petroleum by:  
(check those that apply)

- ☒ bioremediation,  
☐ chemical oxidation, or  
☐ other (describe) \_\_\_\_\_

Brief description of the project: Groundwater remediation treatability study to evaluate the potential for denitrification-based bioremediation to mitigate BTEX/TPH compounds present in groundwater and soil

Summary of major design considerations and features of the project:

Number of injection wells: 2 (wells 18GS28 and 18MW59S - see attached map)  
Injection volume per well (gallons): 130  
Single or multiple injection events: single  
Injection volume total (all wells, all events): 260

## FLUID TO BE INJECTED

Composition of injected fluid (ingredient, wt. %): see attached N-Blend composition (this information is confidential and should be kept as such in accordance with July 2007 letter from FDEP re: Innovative Technology Program for Petroleum Remediation)

## TEMPORARY INJECTION ZONE OF DISCHARGE (ZOD)

(check those that apply)

- ☐ No ZOD needed. The fluid to be injected meets the primary and secondary drinking water standards set forth in Chapter 62-550, F.A.C., and the minimum groundwater quality criteria set forth in Chapters 62-520 and 62-777, F.A.C.
- ☒ ZOD permission by paragraph 62-522.300(2)(c), F.A.C., for reagent chemical species and/or parameter(s) in the fluid to be injected (or re-injected) that exceed secondary groundwater standards. ZOD permission by this paragraph also applies to chemical species in the fluid to be injected that exceed primary groundwater standards or minimum groundwater criteria, provided those species are prime constituents of the reagents used to remediate site contaminants. The list of chemical species and parameters for which the approved remediation plan identifies zone size, duration and groundwater monitoring are as follows:

Nitrates: ZOD length -120 feet; ZOD duration – 0.9 year (see attached calculations)

TDS: ZOD length – 17 feet; ZOD duration – 0.1 year (see attached calculations)

- ☐ ZOD permission by paragraph 62-522.300(2)(c), F.A.C., for the following petroleum products' contaminants of concern that exceed their groundwater standards in the fluid to be re-injected as part of a closed-loop re-injection system for which the approved remediation plan identifies zone size, duration and groundwater monitoring:

- ☐ ZOD permission by variance because the fluid to be injected contains the following impurities that are not prime constituents of the reagents used to remediate the site's contaminants, and the concentrations of those impurities in the fluid to be injected are in excess of their primary groundwater standards:

☐ A variance needs to be granted before the remediation can be conducted.

☐ A variance has already been granted for the impurities listed above:

Date variance granted: \_\_\_\_\_

Zone size (square feet): \_\_\_\_\_

Duration (months): \_\_\_\_\_

- ☐ If ZOD permission by paragraph 62-522.300(2)(c), F.A.C., or by variance is checked above, then a figure that delineates the ZOD is attached, or

- ☐ The ZOD is described as follows: \_\_\_\_\_

## CLEANUP CRITERIA AND ENFORCEABLE APPROVAL ORDER

The in situ injection-type aquifer remediation plan for this petroleum contaminated site is intended to meet the groundwater petroleum cleanup criteria referenced in Chapter 62-770, F.A.C. Additionally, all other groundwater standards will be met at the time of project completion for any residuals associated with the ingredients of the injected remediation products, and any by-products or intermediates produced as a result of the chemical or biochemical transformation of those ingredients or the contaminating petroleum product during their use. Applicable primary and secondary drinking water standards are set forth in Chapter 62-550, F.A.C., and additional groundwater quality criteria are set forth in Chapters 62-520 and 62-777, F.A.C.

The remediation plan estimates that site remediation will take NA<sup>(1)</sup> months. We will notify you if there are any modifications to the remediation strategy which will affect the injection well design or the chemical composition and volume of the injected remediation product(s).

The proposed remediation plan was approved on NA<sup>(1)</sup> by an enforceable approval order. A copy is attached. The remediation system installation is expected to commence within 60 days. Please call me at NA<sup>(1)</sup> if you require additional information.

Notes: (1) - This study is a treatability study to evaluate a remedial technology for consideration of future implementation. It is not a remediation system or intended to be and therefore this information is anticipated to be not applicable.

## **APPENDIX F**

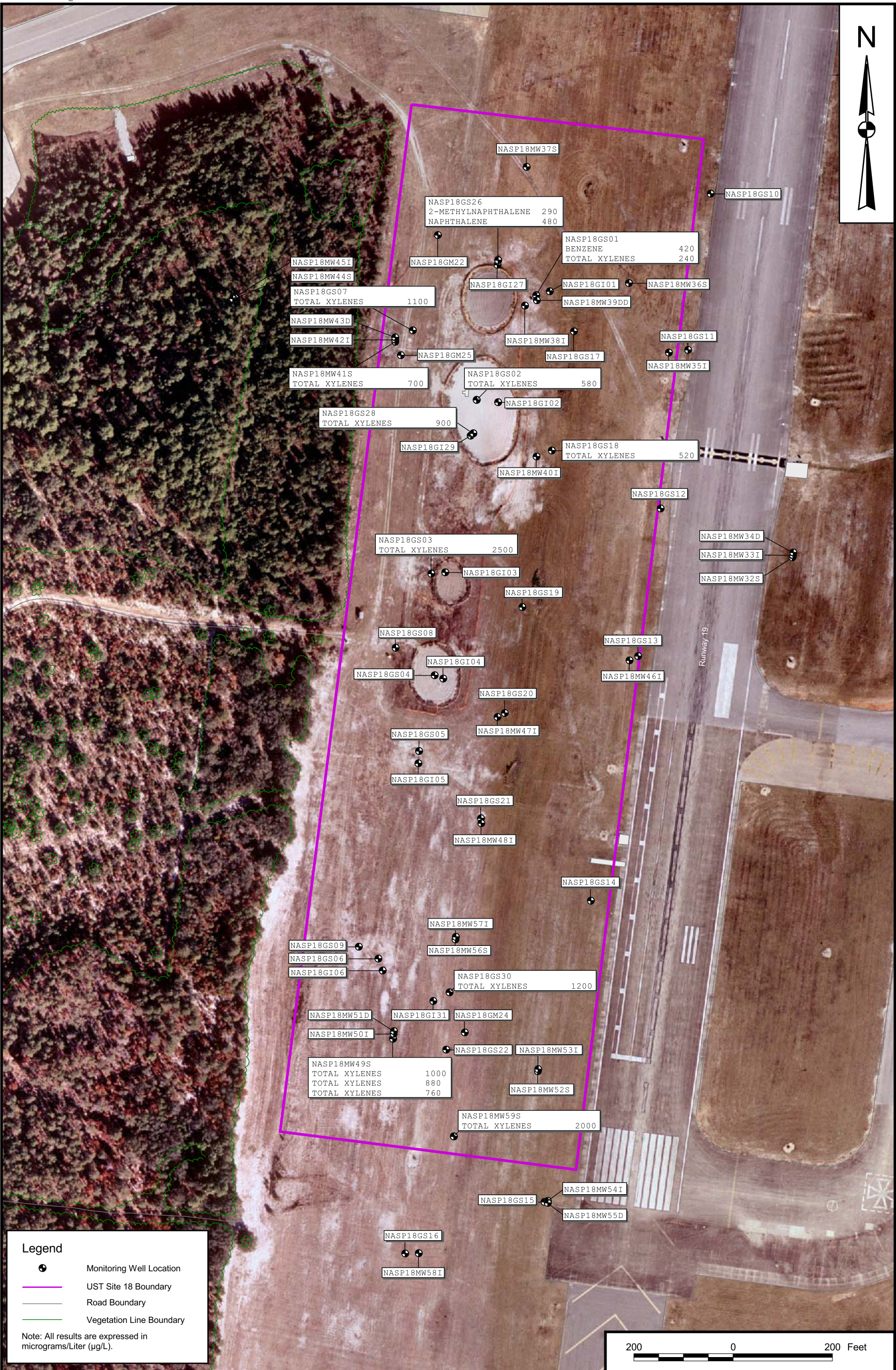
### **MONITORING WELLS WITH FLORIDA NADSCs EXCEEDANCES**







TINUS/TAL-08-088/0005/5.4



DRAWN BY	DATE
S. PAXTON	8/15/06
CHECKED BY	DATE
K. WIMBLE	10/18/06
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	



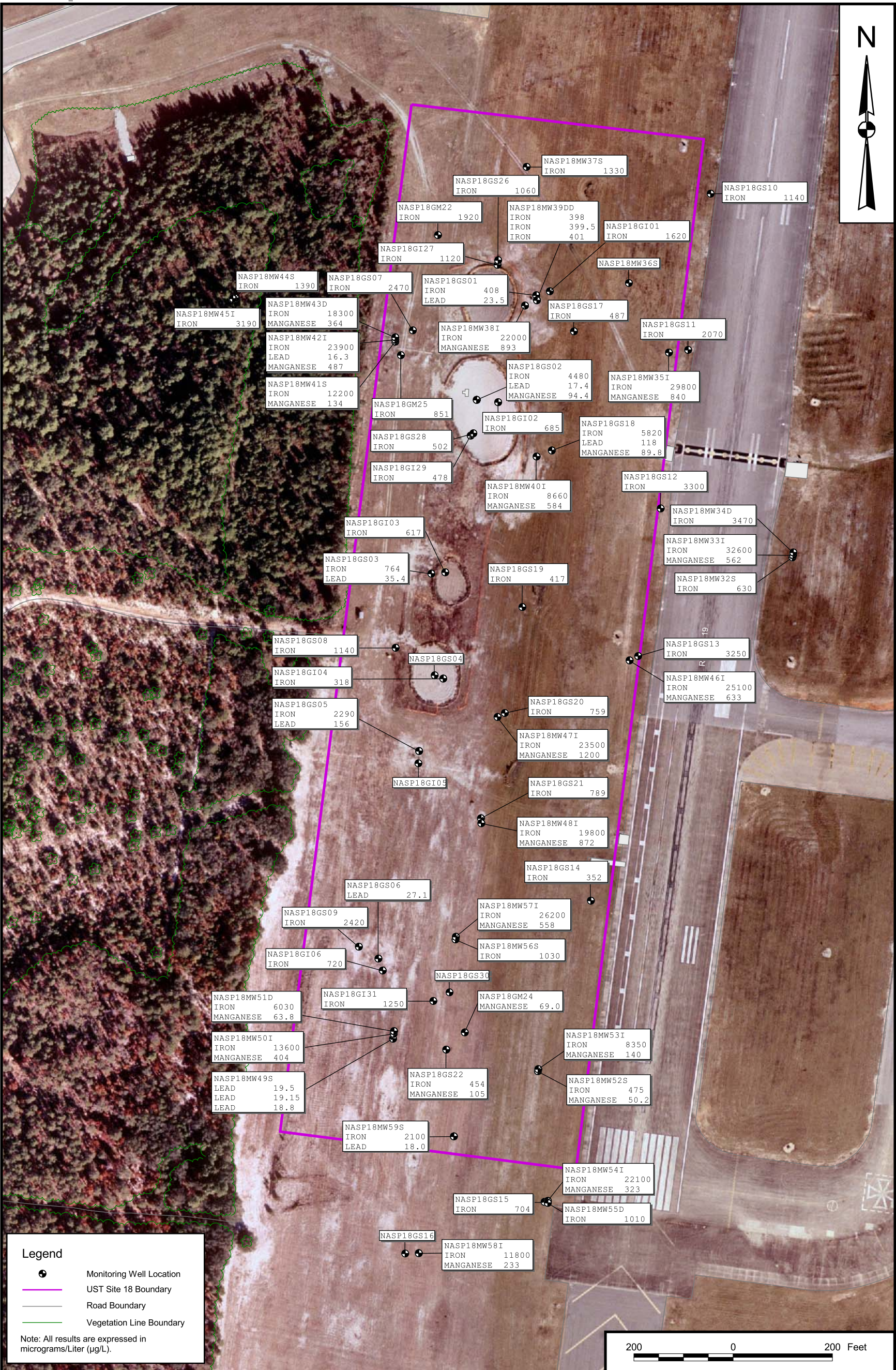
MONITORING WELLS WITH ORGANIC COMPOUNDS  
IN EXCEEDANCE OF FLORIDA NADSCs  
UST SITE 18  
NAS PENSACOLA  
PENSACOLA, FLORIDA


CONTRACT NUMBER	
CTO 0005	
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO.	FIGURE 4 - 6
REV	0

Rev. 1  
10/31/08



TINUS/TAL-08-088/0005/5.4



DRAWN BY S. PAXTON		DATE 8/15/06			MONITORING WELLS WITH INORGANIC COMPOUNDS				CONTRACT NUMBER CTO 0005		
CHECKED BY K. WIMBLE		DATE 10/18/06			IN EXCEEDANCE OF FLORIDA GCTLs				APPROVED BY _____ DATE _____		
COST/SCHEDULE-AREA					UST SITE 18				APPROVED BY _____ DATE _____		
SCALE AS NOTED					NAS PENSACOLA				DRAWING NO. _____		
					PENSACOLA, FLORIDA				FIGURE 4 - 7		
										REV 0	


MONITORING WELLS WITH INORGANIC COMPOUNDS  
IN EXCEEDANCE OF FLORIDA GCTLs  
UST SITE 18  
NAS PENSACOLA  
PENSACOLA, FLORIDA

Rev. 1  
10/31/08



TINUS/TAL-08-088/0005/5.4



DRAWN BY S. PAXTON		DATE 8/15/06	
CHECKED BY K. WIMBLE		DATE 10/18/06	
COST/SCHEDULE-AREA			
SCALE AS NOTED			
			
MONITORING WELLS WITH INORGANIC COMPOUNDS IN EXCEEDANCE OF FLORIDA NADSCs UST SITE 18 NAS PENSACOLA PENSACOLA, FLORIDA			
CONTRACT NUMBER CTO 0005			
APPROVED BY		DATE	
APPROVED BY		DATE	
DRAWING NO.		FIGURE 4 - 8	
		REV 0	

Rev. 1  
10/31/08